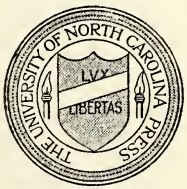
JANUARY, 1928 NUMBER 250

THE UNIVERSITY OF NORTH CAROLINA RECORD

THE SCHOOL OF ENGINEERING

CATALOGUE 1927-1928



ANNOUNCEMENTS
1928-1929

THE UNIVERSITY OF NORTH CAROLINA PRESS
CHAPEL HILL, N. C.

CALENDAR
1928-1929

June 8-11, 1928	*Friday through Monday.* Commencement Exercises.
June 14-July 24	Summer Quarter, First Term.
June 13-August 29	Summer School of Law.
July 25-August 31	Summer Quarter, Second Term.
September 12-15	*Wednesday through Saturday.* Examinations for conditions and Entrance Examinations.
September 17-20	*Monday through Thursday.* Freshman Week. Registration September 19 (Freshmen only).
September 20	*Thursday.* Registration (all except Freshmen) for the fall quarter.
September 21	*Friday.* Class work for the fall quarter begins.
October 12	*Friday.* University Day Exercises.
November 28	*Wednesday.* Thanksgiving Recess begins (1:00 p.m.).
December 3	*Monday.* Thanksgiving Recess ends (8:30 a.m.).
Dec. 17, 18, 19, 20	*Monday, Tuesday, Wednesday, Thursday.* Examinations for the fall quarter. Registration of all except Freshmen and Sophomores.
Dec. 20 (afternoon)-Jan. 1, 1929	Christmas Recess.
January 2, 1929	*Wednesday.* Registration completed for the winter quarter (Freshmen and Sophomores).
January 3	*Thursday.* Class work for the winter quarter begins.
January 26	*Saturday.* First semester School of Law ends.
January 28	*Monday.* Second semester School of Law begins.
February 1	*Friday.* Candidates for the Mangum Medal announce their subjects to their respective Deans.
March 13-16	*Wednesday through Saturday.* Examinations for the winter quarter. Registration of all except Freshmen and Sophomores.
March 16-22	*Saturday afternoon through Friday.* Spring Recess.
March 23	*Saturday.* Registration completed for the spring quarter. (Freshmen and Sophomores).
March 25	*Monday.* Class work for the spring quarter begins.
April 29	*Monday.* Selection of Commencement Orators.
June 3-6	*Monday through Thursday.* Examinations for the spring quarter.
June 7-10	*Friday through Monday.* Commencement.

CALENDAR FOR JUNIOR CO-OPERATIVE STUDENTS

June 11-Aug. 6, 1928	Incoming Juniors in Summer School, eight weeks.
Aug. 6-Sept. 17	Sections I and II on vacation, six weeks.
Sept. 17-Nov. 5	Section I at work. Section II at school. Seven weeks. Registration Section II September 20.
Nov. 5-Dec. 20	Section I in school. Section II at work. Six and one-half weeks.
Nov. 28-Dec. 3	Thanksgiving Recess for Section I
Dec. 20-Feb. 25, 1929	Section I at work. Nine and one-half weeks.
Dec. 20-Jan. 3, 1929	Christmas vacation for Section II. Two weeks.
Jan. 3-Feb. 25, 1929	Section II in school for seven and one-half weeks.
Feb. 25-April 29	Section I in school for eight weeks. Section II at work for nine weeks.
March 16-25	Spring Recess for Section I for one week.
April 29-June 10	Section I at work for seven weeks. Section II in school for seven weeks.
June 10-July 29	Section I in school for seven weeks. Section II at work for seven weeks.
July 29-Aug. 19	Section I at work for three weeks. Section II vacation for three weeks.
Aug. 19-Sept. 16	Section I vacation for four weeks. Section II at work for four weeks.

CONTENTS

PAGE

Calendar 2

Officers of Government and Instruction 4

Introductory Statement 6

Coöperative Engineering Education 9

Coöperation with National Engineering Societies 10

The Engineering Laboratories 10

The Engineering Library and Reading Room 16

Admission 18

Tuition and Other Expenses 19

Registration 22

Assignment of Rooms 23

Degrees in Engineering:

- Bachelor of Science 23
- Master of Science 23

Research:

- Hydraulic and Sanitary Engineering 24
- Highway Engineering 25
- Chemical Engineering 25

Program of Study:

- Electrical Engineering 26
- Civil Engineering 27
- Mechanical Engineering 28
- Suggested Outline of Study for Advanced Students 29
- Chemical Engineering 30

Courses Leading to the Degree of Master of Science 32

Description of Courses 34

Courses for Graduate Students 45

OFFICERS OF GOVERNMENT AND INSTRUCTION

THE UNIVERSITY

HARRY WOODBURN CHASE, Ph.D., LL.D., *President.*
CHARLES THOMAS WOOLLEN, *Business Manager.*
JULIUS ALGERNON WARREN, *Treasurer and Bursar.*
THOMAS JAMES WILSON, JR., Ph.D., *Registrar.*
LOUIS ROUND WILSON, Ph.D., *Librarian.*
ERIC ALONZO ABERNETHY, M.D., *Physician.*

THE SCHOOL OF ENGINEERING

HARRY WOODBURN CHASE, Ph.D., LL.D., *President.*
GUSTAVE MAURICE BRAUNE, C.E., *Dean.*
LOUISE WATSON, *Secretary.*

The Administrative Board

ANDREW HENRY PATTERSON, A.M., Sc.D., *Professor of Physics.*
PARKER HAYWARD DAGGETT, S.B., *Professor of Electrical Engineering.*
JAMES MUNSIE BELL, Ph.D., *Smith Professor of Chemistry.*
WILLIAM FREDERICK PROUTY, Ph.D., *Professor of Stratigraphic Geology.*
THOMAS FELIX HICKERSON, A.M., S.B., *Professor of Civil Engineering.*
ALLAN WILSON HOBBS, Ph.D., *Professor of Applied Mathematics.*
ALMONTE CHARLES HOWELL, Ph.D., *Assistant Professor of English.*
HAROLD FREDERICK JANDA, C.E., *Professor of Highway Engineering.*
ELMER GEORGE HOEFER, M.E., *Professor of Mechanical Engineering.*

The Faculty

GUSTAVE MAURICE BRAUNE, C.E., *Professor of Civil Engineering.*
PARKER HAYWARD DAGGETT, S.B., *Professor of Electrical Engineering.*
JOHN EMERY LEAR, E.E., *Professor of Electrical Engineering.*
THOMAS FELIX HICKERSON, A.M., S.B., *Professor of Civil Engineering.*
THORNDIKE SAVILLE, A.B., M.S., *Professor of Hydraulic and Sanitary Engineering.*
HAROLD FREDERICK JANDA, C.E., *Professor of Highway Engineering.*
ELMER GEORGE HOEFER, M.E., *Professor of Mechanical Engineering.*

Herman Glenn Baity, A.B., M.S., *Associate Professor of Sanitary and Municipal Engineering.*
George Wallace Smith, S.B., *Assistant Professor in Engineering.*
Ralph McCoy Trimble, C.E., S.M., *Assistant Professor in Engineering.*
John McIver Foushee, S.B., *Instructor in Engineering.*
Thomas Bryan Smiley, B.S., *Instructor in Electrical Engineering.*

Other Members of the Faculty

James Munsie Bell, Ph.D., *Smith Professor of Chemistry.*
Alvin Sawyer Wheeler, Ph.D., *Professor of Organic Chemistry.*
William Frederick Prouty, Ph.D., *Professor of Stratigraphic Geology.*
Allan Wilson Hobbs, Ph.D., *Professor of Applied Mathematics.*
Frank Porter Graham, A.M., *Professor of History.*
Frank Carl Vilbrandt, Ph.D., *Associate Professor of Industrial Chemistry.*
Gustav Theodor Schwenning, *Associate Professor of Business Administration.*
James Talmadge Dobbins, Ph.D., *Associate Professor of Chemistry.*
Floyd Harris Edmister, Ph.D., *Associate Professor of Chemistry.*
Joe Burton Linker, Ph.D., *Associate Professor of Mathematics.*
Arthur Simeon Winsor, Ph.D., *Associate Professor of Mathematics.*
Earle Keith Plyler, Ph.D., *Associate Professor of Physics.*
Almonte Charles Howell, Ph.D., *Assistant Professor of English.*
Horace Downs Crockford, S.M., *Assistant Professor of Chemistry.*
Gerald Raleigh MacCarthy, Ph.D., *Assistant Professor of Geology.*
William Olsen, A.B., *Instructor in English.*
Martin Whitford Trawick, A.B., *Instructor in Physics.*
Ralph Walton Bost, A.M., *Instructor in Chemistry.*
Howell Grady Pickett, S.M., *Instructor in Chemistry.*
William Marion Mebane, S.M., *Instructor in Chemistry.*
John West Harris, Jr., M.A., *Instructor in English.*
George Frederick Horner, M.A., *Instructor in English.*
Henry August Pochmann, M.A., *Instructor in English.*
Barrett Lyons, A.B., *Instructor in English.*

INTRODUCTORY STATEMENT

When the University of North Carolina opened its portals in 1795 the first student to seek admission was Hinton James of Wilmington, who, after a distinguished career as a student, engaged in the practice of engineering. Thus, from its very foundation the University of North Carolina has afforded training for engineers.

It is recorded of this first student that his college productions included essays on such diverse subjects as "The Uses of the Sun," "The Motions of the Earth," "The Commerce of Britain," and "The Effects of Climate on the Minds and Bodies of Men." This catholicity of interest, ranging from astronomy to commerce, was a remarkable forerunner of the present engineering curriculum, which includes many subjects remote from strictly technical applications, but which is designed to produce broad-visioned leaders in the constructive development of the state's resources, who may worthily follow the tradition of engineering service so strikingly inaugurated by the first student at the University.

After graduating, James was in charge of channel improvements on the Cape Fear River, among the first improvements to inland waterways to be undertaken in this state. The remains of certain dikes constructed by him are visible today, structures which have persisted in spite of one hundred and forty years of river floods and deposits.

Engineering courses were offered at the University as far back as 1852 when Charles Phillips was made Professor of Civil Engineering, the Department of Civil Engineering being included in the "School for the Application of Science to the Arts." This arrangement continued until the University was closed in 1868. In the first year after the re-opening, 1875-1876, the College of Engineering is listed in the catalogue with an outline of the course of study covering three years. In 1888-1889 Engineering and Mathematics were united under one department, but when the Department of Applied Science was formed in 1904-1905 the engineering courses were included in this Department. The Department of Applied Science became the School of Applied Sciences in 1907-1908 and the Departments of Chemical, Civil and Mining Engineering, and Soil Investigation are listed as parts of this School of Applied Sciences in the catalogue of 1909-1910. The departments of Engineering continued under the School of Applied Sciences until June, 1922, when the School of Engineering was authorized. The School of Engineering now consists of the three departments of Civil, Electrical, and Mechanical Engineering, and also offers a curriculum in Chemical Engineering.

The material and industrial growth of the South is proceeding at such a rate as to require increasing numbers of men trained in design, construction, and administration relating to the control of the great forces of nature for the use and convenience of man. The great highway systems springing into being throughout the South; the new sky-scrapers, office buildings and hotels; the municipal systems of water supply, sewerage, and paving; the public health and agricultural aspects of drainage; the utilization of rivers for navigation and water power; the generation, transmission, distribution, and utilization of electric energy; all these are making unprecedented demands upon technically trained men, not only for designing and constructing, but also for operation and administration.

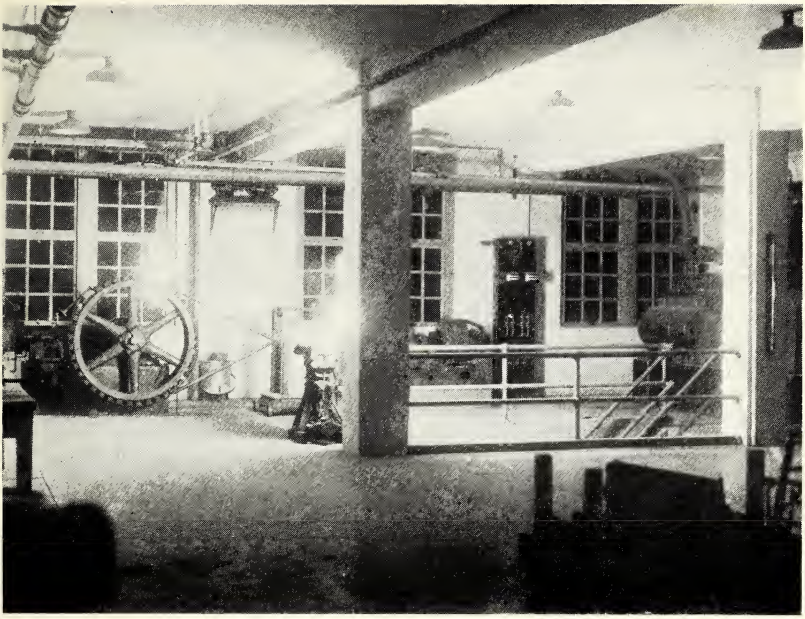
The engineer of today, and of the future, will not only be called upon to contribute in a large measure to the direction of the material welfare of the human race, but also will be concerned greatly with the management of men; and will be selected more and more to fill places requiring much administrative and executive training.

It is becoming generally recognized by engineering educators and by others who are seriously concerned with the training of engineering students that there is a growing tendency to crowd the curriculum with purely technical subjects, thereby neglecting the broader cultural side which is essential in the training of any professional man and which particularly applies to the engineer. The engineering courses, therefore, have been developed along broad and cultural lines and the necessity for cultural training as a part of a thorough technical education has been kept constantly in mind. The importance of English in the curricula has been emphasized. The courses have been arranged so that the students will receive instruction in English throughout the four-year period. Much attention is also given to training in public speaking. This is an acquired art, and a very necessary adjunct of an engineering education. Engineers must be versed in business affairs. To meet this condition students devote considerable time to Economics and Business Administration and Management. During the first three years, the contents of the curricula are practically the same for all engineering students. Fundamentals in Mathematics, Mechanics, and other sciences are contained in these first three years, and the application of these fundamentals is illustrated throughout the courses by the solution of practical problems in engineering.

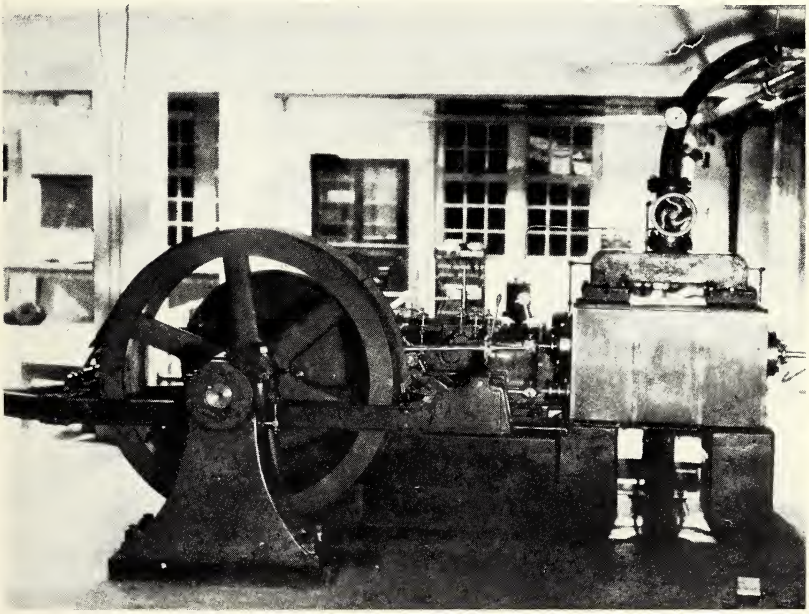
For those whose abilities, inclinations, and opportunities permit intensive training in special branches of engineering the fifth or graduate year has been designed. Especial attention is called to the provisions for graduate study described on pages 23-25. The courses required for a graduate degree in the several special branches of engineering are stated on pages 32-34, and the detailed descriptions are to be found on pages 45-46.

In order to accommodate the growing number of students who prefer to take two or more years of preliminary education in a liberal arts college, the faculty suggests that certain fundamental courses contained in the freshman and sophomore years of the engineering program be included in the courses taken in the liberal arts college. These courses, when submitted for credit, will enable the applicants for the engineering degree to complete the course of study in the School of Engineering of the University in three years. This pre-engineering schedule may be taken at any accredited liberal arts college or in the College of Liberal Arts of the University. For a detailed outline of the suggested courses see pages 29-30.

The intimate contact of engineering students with the academic students affords excellent opportunity for all-round cultural training. Since the School of Engineering is an integral part of the University of North Carolina, which is a member of the Association of American Universities, it is of significant importance that young men who wish to pursue a training in Engineering are also afforded the opportunity of registering as students in a university embracing a strong liberal arts college and thereby reaping the advantages of this cultural association.



PART OF MECHANICAL ENGINEERING LABORATORY



UNIFLOW ENGINE. MECHANICAL ENGINEERING LABORATORY

Digitized by the Internet Archive
in 2014

http://archive.org/details/universityofnort250univ

THE SCHOOL OF ENGINEERING

CO-OPERATIVE ENGINEERING EDUCATION

For a number of years a great amount of time and thought has been devoted to engineering education by engineering teachers and the profession at large, with the idea of adopting some method in engineering education that will develop the observation and initiative of the students and bring them in touch with the practical side of the engineering profession during their theoretical training.

In order to meet this situation, the University of Cincinnati installed in the fall of 1906 a method of accomplishing this which is called coöperative education. Under this plan, the students spend half of their time at the University receiving their theoretical training, and the other half with engineering industrial firms, thus getting practical training during their collegiate period. This system of education has proved so successful that it has been adopted by a number of prominent institutions, among which are Massachusetts Institute of Technology, the University of Pittsburgh, and New York University. The method of coöperation has been modified by several of the institutions that have adopted this system; for example, a plan has been arranged whereby only the junior class coöperates with the outside industries. This modified plan permits the students to get in touch with outside practice, but does not destroy the social and cultural contact which the students derive from full-time association on the University campus during the greater part of their college course.

Realizing that the coöperative system of training young engineers is a distinct step forward, the School of Engineering of the University of North Carolina adopted this plan of education in September, 1922.

Under this plan, the students of the junior class are divided into two groups designated as Sections I and II. Each group spends half of its time at the University, and the other half in actual engineering work. Each student has an alternate so that when a student of Section I is at school his alternate in Section II is on the job. At definite intervals the student from Section II goes to school while his alternate in Section I takes his place on the job. This alternation continues throughout the junior year up to the latter part of September. Both sections attend the University full time during their senior year.

The Chemical Engineering students acquire their coöperative work during the summer between the junior and senior years by

employment in the operative department of one of the several chemical plants in the state. The equivalent of eight weeks' employment in any operative capacity is accepted for this credit. Chemical laboratory experience is not accepted as equivalent to eight weeks' operative work.

In order to compensate for the time that the students are away from school during their junior year, at the completion of the sophomore year the students register for a summer term of eight weeks. Coöperation in the junior year continues until September of the senior year. The students receive pay for their services during the time that they are on their outside work, thus enabling them to defray part of their expenses during the junior year. This system of education has been received very favorably by the industrial firms of the state.

At the present time the School of Engineering is coöperating with the following: The State Highway Commission; the City of Charlotte; Southern Power Company; R. H. Bouligny, Inc.; Tidewater Power Company; Caldwell Power Company; Southern Railway Company; Grady L. Bain, Consulting Engineer; North Carolina Department of Conservation and Development; and the University of North Carolina Consolidated Service Plants.

CO-OPERATION WITH NATIONAL ENGINEERING SOCIETIES

Two national professional societies, the American Society of Civil Engineers and the American Institute of Electrical Engineers, have established student chapters in the School of Engineering, and through these societies the students are given opportunities to bring to the University engineers of national reputation to talk on engineering subjects.

THE ENGINEERING LABORATORIES

A marked characteristic of this School is its well-equipped laboratories which are housed in Phillips Hall and include the facilities of Venable Hall.

Laboratory instruction is recognized as an important element of an engineering education, and with the excellent laboratory facilities the students study the fundamental laws of engineering.

The following descriptions indicate the major equipment of the engineering laboratories.

Materials Testing Laboratory

The Materials Testing Laboratory is equipped with a 100,000-pound Riehlé Universal testing machine and a 200,000-pound Olsen machine, both of which are used in tensile, compressive, and transverse tests of all structural materials. Special features of these machines make possible the testing of long columns and beams and the cold-bend test of metals.

Numerous smaller pieces of apparatus are provided for studying the elastic properties of materials, annealing and tempering of metals, fire resistance of stone and clay products, hardness of materials, shearing strength of timber, etc.

A complete set of apparatus for making all the standard tests of cement and miscellaneous equipment for routine tests or research work on sand, coarse aggregate, mortar, and concrete is in use.

Civil Engineering Laboratories

The Highway Engineering Laboratory is equipped with apparatus for the standard tests of bituminous and non-bituminous road-surfacing materials, consisting in part as follows: Engler viscosimeter, penetrometer, ring and ball melting-point apparatus, open cup oil tester, New York Board of Health oil tester, Hubbard-Carmick specific gravity flask, hydrometers, float testing apparatus, constant temperature and drying oven, ductility machine, Dulin rotarex, Deval 4-cylinder abrasion machine, diamond core drill, diamond saw, grinding lap, Page impact, ball mill, briquette former, cementation machine, etc.

The Hydraulic Laboratory occupies a separate building adjacent to Phillips Hall. It is equipped with apparatus to show the phenomena of flow of water in pipes, including hydraulic gradient, friction loss, venturi effects, pitometer traverses, etc. Large orifice and weir tanks provide opportunity for experiments on the discharge of water through these measuring devices. Facilities are also available for experiments on friction loss and discharge through hydrants, pipe lines, and nozzles, the testing of meters, the determination of total pressures on submerged areas, etc. Measuring tanks are provided of sufficient capacity to make practical demonstrations of hydraulic phenomena occurring in practice and to permit of research on hydraulic problems.

A model gaging station of the standard type of the U. S. Geological Survey has been installed on Morgan's Creek, the source of the University water supply. This is equipped with an Au water-stage register. Students are given practical experience in stream gaging, and a part of the laboratory instruction includes also the making of meteorological observations at the U. S. Weather Bureau rainfall and evaporation station located on the campus.

The new laboratories of Sanitary Engineering are located in the building of the University water purification plant, in a wing of Phillips Hall. They comprise: a biological room equipped for microscopic and bacteriological work, which also contains plan files and an extensive reference library of sanitary engineering literature, making it suitable for seminar, laboratory, and reference purposes; a chemical laboratory with equipment for conducting any of the determinations ordinarily required in sanitary chemistry; a preparation room for the cleansing and sterilization of glassware

and the preparation of reagents and culture media; a dark room for ultramicroscopic, photomicrographic and turbidimetric work; a chemical storage and balance room; a private laboratory; and a research laboratory for the use of graduate students doing special research work.

These laboratories are well equipped with apparatus for carrying on the usual physical, chemical, and biological analyses of gases, milk, water, sewage and industrial wastes, for the testing of sands and other materials used in sanitary engineering works, for studies of corrosion, for limnological and stream-pollution investigations, and for experimental and research work in the field of sanitary engineering. The water filtration plant is used for demonstration and experimental purposes in the study of problems of water purification; three types of sewage treatment plants located in town afford an opportunity for the study of waste treatment and stream pollution; and nearby towns with excellent sanitary plants coöperate with the School in providing facilities for the investigation of the various problems of municipal and public health engineering.

The Surveying Laboratory equipment comprises a number of transits, levels, plane tables, and auxiliary instruments, such as level rods, chains, range poles, stadia rods, Locke levels, telescopic alidades, sextant, barometer, etc. Enough instruments are furnished to insure the least possible number of students in each field party, so that each student will receive a maximum of practice at the instrument. All the modern types of instruments are represented so that the student may become familiar with the different manufacturers' products.

Electrical Engineering Laboratories

The Electrical Engineering Laboratories consist of a large Dynamo Laboratory, having over three thousand square feet of floor space, on the ground floor of the main section of Phillips Hall, and seven special laboratories on the second floor of the new wing. They are all supplied with power through a seven-panel slate switchboard in the main laboratory which feeds twenty distribution panels in the different laboratories. Most of the sub-panels are connected with the main board by ten wires and a plug and socket system which makes it possible to supply any of the laboratories with several different kinds of power at the same time. The main power supply consists of a 25-kw., 125-volt direct current motor-generator set, a 5-kw., 6- or 12-volt electrolytic type motor-generator, and three-phase, 110- and 220-volt circuits of 25-kw. each. There is also available a 4-kw., three-phase alternator having a practically pure sine wave for use in iron testing.

The Dynamo Laboratory contains some forty machines, mostly of modern design, including a 15-kv.a. General Electric motor-

generator set with revolving field alternator wound for single-, two-, three-, or six-phase, two 5-kv.a., Westinghouse M. G. sets, two 10-kw. synchronous converters, two 5-kw. and two 3-kw. direct current M. G. sets, a 3-hp. General Electric Type RF variable speed motor with compensating winding in the pole faces, a 5-hp. General Electric 3-phase induction motor with wound rotor and drum type controller, a 3-hp. General Electric Type RI repulsion motor, and a number of other machines ranging from two to ten horsepower.

A mezzanine gallery at one end of the laboratory contains a 50,000-volt and a 10,000-volt testing transformer, a number of distribution and laboratory type transformers, as well as a 50-ampere General Electric mercury arc rectifier.

More than one hundred portable ammeters, voltmeters, and wattmeters are available for routine testing.

Standardization Laboratory. A special laboratory for the standardization of instruments contains the following precision laboratory standards: A 150-volt Western d.c., voltmeter, a millivoltmeter with complete set of shunts up to 1000 amperes capacity, a 5-10-ampere Westinghouse Kelvin-balance type ammeter, a 200-ampere, 300-volt Kelvin-balance type wattmeter, and a 150-ampere, 440-volt, 3-phase States test table for checking watt-hour-meters with General Electric and Westinghouse rotating standards. The precision instruments are mounted on 24 x 48 inch slate table tops set in concrete piers, and each test station is permanently wired with all the necessary control equipment so that the calibration of any instrument may be quickly checked.

Photometric Laboratory. This contains a standard Reichsanstalt photometer bench with three-meter track equipped with standard track screens for daylight work, Bunsen screen, Lummer-Brodhun disappearance and contrast screens, standard Hefner lamp, a number of certified carbon and tungsten incandescent standards, a compound rotator, a luxometer and a General Electric Foot-Candle meter for illumination surveys and a number of shades and reflectors of various types. The laboratory is also supplied with constant potential and constant current arc lamps, direct and alternating current types, a 4-ampere magnetite arc, 12-ampere flaming-arc, and 3.5-ampere mercury-arc.

Freshman Laboratory. A special feature of the instruction in electrical engineering at the University is the freshmen course. The student begins his study of the basic principles of the electrical engineering profession at the beginning of the freshmen year. The lectures, reading, and assigned problems are accompanied by work in a specially-equipped laboratory. Here standard electrical engineering equipment is used in illustrating the fundamental principles of electricity. Various exhibits donated by the manufacturers

illustrate the constructional details and manufacturing processes of electrical apparatus and supplies. During the course each individual is studied with a view to guiding his future work into channels for which he is obviously best fitted.

Telephone and Radio Laboratory. A special laboratory is equipped for work in telephone transmission and radio-frequency measurements. There is available a variety of standard telephone equipment including transmitters, receivers, repeating coils, etc., and a 32-mile standard artificial line.

The facilities for radio measurements include General Radio Company decade and capacity bridges, precision wave-meter, precision condenser, vacuum-tube bridge, and low-frequency oscillator. The laboratory contains the usual complement of coils, condensers, variometers, hot-wire and thermo-couple meters and practically all types of vacuum tubes. Receiving sets of all types, from the simple regenerative circuit to the most complicated super-heterodyne, are available for reception in the broadcast range.

Radio Station 4WE. A separate room is provided for the radio station operated by the Department under the call letters 4WE. This station, which is an official relay station of the American Radio Relay League, has been operating with a 50-watt crystal-control transmitter on the 40-meter wave band, and has been in communication with amateur stations in Sweden, France, Morocco, Chile, Argentine Republic, South Africa, Australia, and New Zealand.

Measurements Laboratory. For work in electric and magnetic measurements there is a large laboratory equipped with several bridge testing sets, a Kelvin double-bridge, Queen-Gray potentiometer, capacity bridge, Leeds and Northrup ballistic and D'Arsonval galvanometers of high sensitivity, and precision standards of resistance, inductance, and capacity. There is also a standard Epstein apparatus for the measurement of iron losses.

Research Laboratory. A separate room is equipped for the study of special research problems. It contains a complete General Electric oscillograph and has a small dark room for photographic work.

Mechanical Engineering Laboratories

The Mechanical Engineering Laboratories are located on the ground floor of the new wing of Phillips Hall, the main laboratory occupying the greater part of this floor.

The principal laboratory is equipped for making experimental studies of power plant apparatus. It contains a 25-horsepower Chandler and Taylor slide-valve engine especially equipped with indicator reducing-motion, prony brake, surface condenser, and indicator piping for experimental work. A 10-inch by 15-inch uniflow steam engine especially built and equipped for laboratory work

by the Fitchburg Steam Engine Company provides for a wide range of experiments. It is equipped with cylinder-head jackets, which may be cut out if desired; and the auxiliary exhaust valves are so constructed and operated through a link that the amount of compression can be regulated while running for conditions varying from a 26-inch vacuum up to 10 pounds gauge back-pressure. The laboratory also contains a two-stage, 25-kilowatt, 250-volt General Electric turbo-generator set for operation either condensing or non-condensing. Both the uniflow engine and the turbine are served by a Wheeler surface condenser capable of condensing 3,000 pounds of steam per hour. Other equipment includes a 40-horsepower compound marine engine, designed and built by the Bureau of Steam Engineering of the United States Navy, two small gas-electric lighting units, and two variable-pressure steam testing drums, together with such smaller equipment as calorimeters, flowmeters, thermometers, indicators, scales, dynamometers, and other necessary apparatus for making complete tests on power plant machinery.

Under a portion of the main laboratory is a sub-basement for condensers and water measuring apparatus.

Adjacent to the main laboratory is a small laboratory for light testing work, such as calibration of instruments, flue-gas analysis, fuel analysis, and fuel and oil testing. It is provided with a Parr oxygen bomb coal calorimeter, a Junker gas calorimeter, a Saybolt universal viscosimeter, a Hays gas analyzer, and other instruments for analyzing and testing fuels and oils.

As a valuable aid in visual instruction and practical experience, the University Power Plant is also available for laboratory purposes. The principal equipment of the plant consists of the power boilers and large uniflow engine. The boiler-room contains one 450-horsepower and two 168-horsepower Babcock and Wilcox boilers, one 350-horsepower Union Iron Works boiler, one 450-horsepower Stirling boiler, a 500-horsepower Cochrane feedwater heater, and three large exhaust and live steam heaters for the hot water heating system of the University. The engine room contains a 750-k.v.a., 2300-volt General Electric alternator driven by the uniflow engine, a 200-kilowatt, three phase, 2300-volt General Electric turbo-generator and switchboard for controlling the electrical equipment. The pump room contains three turbine-driven centrifugal pumps for circulating hot water through the heating system and motor-driven service and fire pumps.

Chemical Engineering Laboratories

The Chemical Engineering Laboratories, located in the southwest section of Venable Hall, consist of a large chemical equipment and process room, and five small adjoining testing laboratories. The equipment and process room has headroom sufficient to permit the set-up of factory-size equipment, and is provided with a traveling

crane. A balcony on one side, and a ledge around the other walls of the room at the twenty-foot level, provide support for temporary flooring for high-level equipment. This room is amply lighted by two full length inclined bays, and is equipped with a ten-inch Shriver plate filter press, a twelve-inch Oliver continuous filter, a Knight monkey pump, a Kent paint mill, a Duriron steam-jacketed kettle, a horizontal steam still, an arc furnace, an 18-inch Tolhurst centrifuge, a Buflovak vacuum shelf dryer, a seamless Dopp kettle with composite accessories for all types of agitation, a 50-pound refrigeration plant, two aluminum-jacketed solution kettles, and a Ford motor for experimental study. Steam, compressed air, water, and gas are supplied to all parts of the laboratory. Outlets for both alternating and direct current are distributed about the laboratory. Vacuum is provided by steam jet evacuators. The five adjoining testing laboratories are completely equipped with the necessary and latest laboratory apparatus for the testing of water, coal gas, petroleum, oils, iron, and steel and for work in assay and metallography. A special laboratory is provided for dark room in connection with metallography and photomicroscopy. Sampling and grinding equipment for the Department of Chemistry is also located in these rooms. Two small arc furnaces, one large and one small resistance heater, and one gas-fired furnace for high temperature studies are located in one of these testing laboratories.

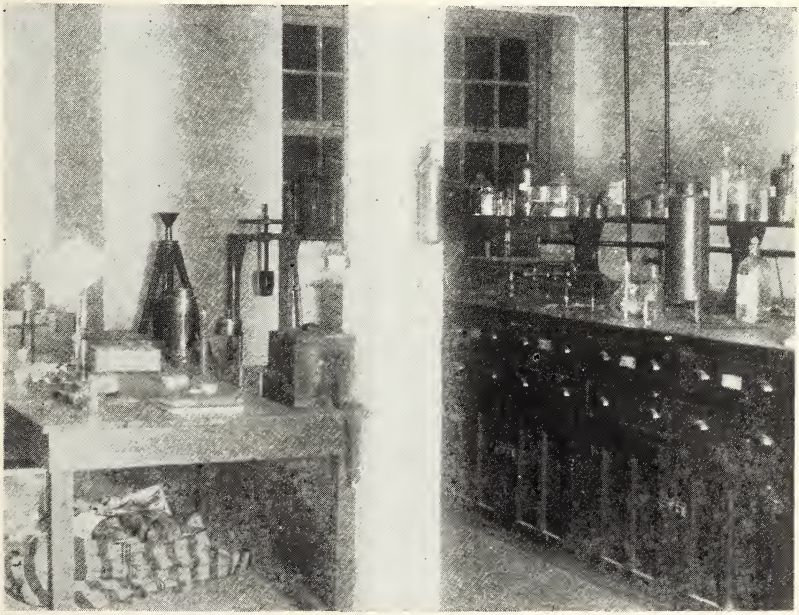
In addition to the above, the equipment and facilities of the entire Department of Chemistry are at the disposal of the students in Chemical Engineering for special studies.

THE ENGINEERING LIBRARY AND READING ROOM

The engineering library and reading room is located at one end of Phillips Hall. It contains 1600 volumes of technical books dealing specifically with the various branches of engineering and 1500 volumes of bound engineering periodicals, and is very well equipped for reference and research purposes.

All of the standard engineering periodicals published in this and foreign countries are regularly received, together with numerous periodicals relating to the business and economic phases of engineering. Complete sets of such standard proceedings as those of the American Society of Civil Engineers, American Institute of Chemical Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Institute of Mining Engineers, *Journal* of the Institution of Engineers (British), National Electric Light Association, *Journal* of the Franklin Institute, etc., are available, and the current numbers kept on file. In addition, the scientific publications of the United States Government and of the various technical institutions and universities are regularly received.

PART OF THE MATERIALS TESTING LABORATORY



HIGHWAY LABORATORY

The Engineering Library is constantly increasing its collection of domestic and foreign publications, and in general when special books are needed for research, or other purposes, arrangements may be made for their purchase. When rare treatises and technical publications, not generally purchasable, are desired they may be obtained by a working agreement with the Library of Congress, whereby such publications may be loaned to the Engineering Library.

The libraries of the Departments of Physics and Mathematics are contained in the same room with the Engineering Library. These libraries number some 3500 volumes, many of which are extremely rare and important foreign works. These libraries also receive the domestic and foreign periodicals devoted to physics and mathematics.

The library of the Department of Chemistry is located in Venable Hall. This library contains some 8000 volumes, consisting of many technical books and periodicals on both pure and applied chemistry from the United States, Canada, England, France, Germany, Italy and Austria. Ample lighting and study space are provided in this modern library.

The association of the four libraries makes an ideal working arrangement, whereby the advanced student is enabled to consult conveniently books in these allied branches of science.

ADMISSION

ADMISSION TO THE UNIVERSITY

Evidence of successful vaccination against smallpox is a prerequisite for the admission of students to this institution. Applicants for admission to any school are hereby informed that a certificate as to successful vaccination must be sent to the Registrar before they can be admitted.

Candidates for admission to the University are received by certificate from accepted schools or by examination.

Entrance by Certificate. Students who present certificates of work accomplished at preparatory schools and colleges may be admitted without examination, provided the certificates are approved. The right to examine, however, is reserved when such a course is deemed necessary. Certificates must be made out on the printed forms furnished on application to the Registrar, and should be sent in as early as possible in the summer vacation; the uniform entrance certificates of the Association of Colleges and Secondary Schools of the Southern States will also be accepted. Candidates must present themselves in person before the Committee on the Registration of Freshmen during the period of registration.

Entrance by Examination. Entrance examinations are held in September. The University will accept the uniform entrance examination papers of the Association of Colleges and Secondary Schools of the Southern States, provided such papers are properly vouched for and sent sealed to the University for grading. The University will accept also the certificates of the College Entrance Examination Board. Candidates for admission by examination must make application to the Registrar in writing two weeks before the date for registration. Time and place for examinations will be arranged by the Registrar.

Admission to Advanced Standing

A candidate for advanced standing may be admitted to the sophomore, junior, or senior class, in accordance with the amount and character of his previous training. The Registrar will accept, with proper restrictions, the official report of work satisfactorily completed at a college or university of good standing. All credits allowed by him stand in suspense until the candidate shall have spent one quarter in residence. If his work during this quarter is unsatisfactory, the credits may be cancelled.

In case of students who enter with advanced standing from other institutions the minimum requirements of residence and credits secured in residence are as follows: residence for three quarters within a period of twelve months and a full year's work comprising at least nine courses or the equivalent.

A candidate for advanced standing must send to the Registrar his application accompanied by an official transcript of his previous record at least two weeks before the date for registration. Blank forms may be secured by writing the Registrar. Notice is hereby given that applicants whose records at other institutions do not reach the standard required for the readmission of students at this institution will not be admitted.

Entrance Requirements

For admission to the University of North Carolina fifteen units secured by the completion of a four years' high school course are required. The applicant must either present an official certificate showing his preparatory work and the recommendation of his school, which must be on the list of accepted schools, or stand entrance examinations on an equivalent amount of preparatory work.

Candidates for admission to the School of Engineering must present credit in the following subjects:

English	3 or 4 units
American History	1 unit
Mathematics, including one-half unit in Solid Geometry	3 units
Latin, Greek, French, German, or Spanish	2 units
Science	1 unit
Electives	5 or 4 units
Total	15 units

In addition to the above specific requirements the candidate must offer as electives the four or five units from the following subjects necessary to complete the total fifteen units: History, Latin, French, German, Spanish, Botany, Chemistry, Physics, Physiology, Zoology, General Science, Physiography, Drawing, Civics, Vocational Subjects: Commercial Geography, General Agriculture, Bookkeeping, Commercial Arithmetic, Stenography and Typewriting, Manual Training.

TUITION AND OTHER EXPENSES

The University reserves the right to make, with the approval of the proper authorities, changes in any fees at any time.

Tuition

	Residents of North Carolina	Non-Residents of North Carolina
Tuition fee for each quarter	$33.34	$41.67
*Registration fee each quarter	12.00	12.00

* This fee includes the gymnasium fee, the library fee, the fee for attendance of the University physician, the fee for debates.

Publications fee each quarter	1.66	1.66
Laundry fee each quarter	8.50	8.50
Total for each quarter	$55.50	$63.83
Summer school tuition for sophomores	$25.00	$25.00
Fee for junior coöperative students each quarter in addition to above	$ 7.00	$ 7.00
Total each quarter for junior coöperative students	$62.50	$70.83

Fees

Laundry Fees: Students will be required to send their washing to the University Laundry for which a deposit will be collected at the time of registration.

Laboratory Fees: Every student taking a laboratory course must pay, in addition to his tuition fee, a small fee for power or materials used in the laboratory. The fees for the various laboratory courses are as follows:

ENGINEERING

†6abc	$ 4.00 a quarter
11bc	3.00 a quarter
16c	2.00
22ac	3.00 a quarter
23s	10.00
32bc	3.00 a quarter
35a	3.00
35bc	4.00 a quarter
45abc	3.00 a quarter
50abc	5.00 a quarter
60abc	5.00 a quarter
61abc	4.00 a quarter
62abc	4.00 a quarter
73abc	5.00 a quarter
74abc	7.00 a quarter
75abc	3.00 a quarter
90abc	5.00 a quarter
91abc	2.00 a quarter
93abc	5.00 a quarter
94abc	5.00 a quarter
110a	10.00

CHEMICAL ENGINEERING

1b	$10.00
6c	10.00
7c	10.00
11-12	7.00 a quarter

CHEMISTRY

1-2E	$ 5.50 a quarter
31	10.00
41	10.00
42	10.00

† Electrical Engineering students are not required to pay laboratory fee for 6c.

45	10.00	
61	10.00	
62	10.00	
81	7.00	
82	7.00	
21-22-23	10.00	a quarter

Geology

3-4	$ 5.00	a quarter
18-19-20	3.50	a quarter

Physics

1-2-3	$ 2.50	a quarter

Board

Excellent board is furnished at Swain Hall for $22.00 a month. A few students can earn their board by waiting on the tables.

Board without room can be obtained in the town from $22.50 to $35.00 a month.

Dormitory Accommodations

Accommodations for nearly thirteen hundred students are available in the University dormitories.

All rooms in the dormitories are completely furnished. Students will, however, provide their own pillow, bed linen (for single beds), and towels.

Room rent ranges from $5.00 to $9.50 a month for each occupant, the price depending upon the location of the room. This charge includes light, heat, and service.

LEAR LOAN FUND FOR ENGINEERING STUDENTS

As a loan for engineering students, the interest on $5,000 is available.

SELF HELP

It is confidently believed that no institution offers wider opportunity for self-help to meritorious students of slender means. The desire is that no worthy boy, however poor, shall ever be turned away for lack of means. To such the University and town offer unusual opportunities for support. Many students are now working their way through college by every form of honorable labor. A number are here as a result of money earned or borrowed. A few students are selected by the authorities as waiters at Swain Hall. Otherwise, all opportunities available in the University and town must be secured by the personal efforts of the individual, or with the assistance of the Faculty Committee on Self-Help, of which H. F. Comer is secretary. They are not assigned by the President.

REMOVAL OF CONDITIONS

Special examinations for students who have been officially excused from regular examinations on account of sickness or have

been absent on account of some necessary cause may be held at suitable times fixed by the Registrar and the instructors concerned. Such examinations must be taken within twelve months of the date of absence.

Special examinations may be taken by students who have received the condition grade (E) at the period of the special examinations in the week preceding the opening of the session in September.

Provided he has no conflict with a course regularly taken by him in the term, such a student may take an examination at the *first* regular term examination in the same subject after he has made the grade E.

Under no circumstances may a student stand a special examination to remove a condition grade (E) between the first and the last class days in any quarter.

To be entitled to take a special examination in term, or at the September period, or at a regular term examination period, the student is required to file with the Registrar at least one week prior to the examination period a written notice that he desires to take such examination.

A grade of I (incomplete) may be converted into one of the regular grades by the completion, within a period of one year, of additional work assigned by the instructor. A grade I not so converted becomes F.

REGISTRATION

All students are expected to present themselves for registration Wednesday or Thursday, September 19 or 20, 1928, between the hours of 9 a.m. and 5 p.m., at the places announced in the plan for registration. Freshmen are expected to complete their registration on Wednesday, September 19; all others on Thursday, September 20. For the winter and spring quarters the same hours will be used for freshmen and sophomores on days fixed by the calendar for the registration of students. All other students must register during the examination period in December and March according to a schedule published immediately before these examinations begin. Registration in case of such students is not considered completed until they have attended all their classes on the first day of the new quarter.

DELAYED REGISTRATION

The penalty for delayed registration for the winter and spring quarters is one month of strict probation for each day of delay. No excuses will be accepted.

Each student registering later than the day appointed for his registration for the winter or the spring quarter must pay five dollars ($5.00) as an additional fee for delayed registration.

Students desiring to change their courses must make written application to the Dean for the desired change. The application will be considered by the Dean and will be granted only after a careful consideration of the facts in each case. A fee of twenty-five cents will be charged for each item of change.

ASSIGNMENT OF ROOMS

The rooms in the University dormitories are assigned to students by the Treasurer in the order of application, subject to the special regulations given below.

The University reserves the right to require any student whom for any reason it considers an undesirable tenant to vacate a room in the University buildings.

All occupants are required to sign a contract, subject to the following special rules:

In order to retain his room for the next session, a student must file with the Treasurer before June 15 a room contract properly signed and a deposit of $5.00. By December 15 another deposit of $5.00 must be made in order to retain the room for the winter and spring quarters. Double rooms must be signed for by both intending occupants. The rooms thus signed for will be retained until September 1 and January 1 respectively, when balance of rent is due. The $5.00 deposit will be forfeited in case the signer or signers do not themselves occupy the room and pay the full rent. Rooms not signed for or made vacant by failure to pay at the proper date will be assigned in the order of application.

The right to occupy a room is not transferable and terminates with the expiration of the lease. Any attempt on the part of an occupant of a room to sell or transfer his right to occupancy shall be deemed a fraudulent transaction. The penalty for violating this rule shall be the forfeiture of the room by the new lessee.

The occupant of a room will be held directly responsible for any damage done to the furniture in his room or to the room.

No dogs shall be kept in the University dormitories. Breach of this regulation leads to forfeiture of the room.

DEGREES IN ENGINEERING

Bachelor of Science

The degree of Bachelor of Science in Chemical, Civil, Electrical or Mechanical Engineering will be conferred on students who have satisfactorily completed the four-year undergraduate program as listed under the department heading.

Master of Science

Those students who have satisfactorily completed a four-year undergraduate program and who are desirous of specializing further in some particular branch of engineering may spend an addi-

tional year at the University, and, after completing satisfactorily a prescribed course of study, may be awarded the degree of Master of Science. Graduates in engineering from institutions having undergraduate courses substantially equivalent to those given at the University of North Carolina may be admitted to graduate study either as special students or as candidates for the Master's Degree. The curriculum is essentially elective, courses to be chosen by the student to meet his individual preferences for a field of concentration. Nine full courses of advanced character are ordinarily required for the degree; six of these will usually lie in the candidate's major field of study, the other three being elected in subjects allied to that field. The courses required for a graduate degree in the several special branches of engineering are stated on pages 32-34, and detailed descriptions are to be found on pages 45-46.

Distinct opportunities for research and graduate study are offered in all departments of the School. Through the close coöperation with the State Highway Commission, the State Board of Health and other agencies, many interesting problems are presented in the field of research which qualified students may undertake, and the laboratories are designed with the idea in mind of offering the student opportunities for carrying on such research work.

At present four research fellowships established by the State Highway Commission (two), North Carolina Department of Conservation and Development, and the City of Durham, N. C., are available for graduate students. These fellowships are open to students who have received a Bachelor's Degree in Engineering and have attained a high scholarship record in their undergraduate work.

RESEARCH

Hydraulic and Sanitary Engineering

The facilities at the School of Engineering for investigating special problems in hydraulic and sanitary engineering are exceptional, and a number of valuable research projects have been completed by graduate students and the instructional staff. Arrangements can be made whereby such work may be carried on by graduate students investigating problems submitted by state or government departments, municipalities, or private firms. As an example of research work, an investigation of problems of sewage and textile waste of Durham, North Carolina, is now in progress. Experimental treatment plants of different types have been built and operated, and a graduate fellowship maintained through funds provided by the City of Durham. In coöperation with the Chlorine Institute and the Town of Chapel Hill, an extensive investigation on the use of chlorine in sewage treatment processes has been started. Another graduate student holding a special fellowship is

Electrical Measurements Laboratory

Electric Machinery Laboratory

investigating the periodicity and distribution of rainfall together with temperature, humidity, and evaporation in North Carolina. In addition, extensive investigations are in progress at Durham, North Carolina, in coöperation with the city, in relation to rainfall, evaporation, stream-flow, and silting on the new Durham water works reservoir, Lake Michie.

Special attention is called to the unique facilities for conducting studies on water and sewage treatment. A modern one million gallon per day water filtration plant is in the same building with the sanitary engineering laboratories. Three types of sewage treatment plants in the town are available for investigation under actual operating conditions.

The hydraulic laboratory is well equipped to conduct investigations on all kinds of hydraulic apparatus and studies in hydrology.

Highway Engineering

In coöperation with the North Carolina State Highway Commission and the United States Bureau of Public Roads, various research problems in highway engineering are being conducted by the School of Engineering.

A study on the action of capillary moisture in highway subgrades has been completed, and the results of this experiment have proved valuable, as they indicate basic principles on the stabilizing of subgrades. These results have been summarized in the Engineering *News-Record,* December 4, 1925.

An experiment on vertical earth pressures is being conducted at the present time. The results of this study promise to be of value to the engineering profession in the design of culverts, culvert pipe, and other underground structures subject to vertical earth pressure. A progress report of this work has been printed in *Public Roads,* the monthly publication of the United States Bureau of Public Roads.

In conjunction with the earth pressure study, a series of experiments has been conducted on the determination of the co-efficients of friction and cohesion of various soils under various loading conditions.

Other highway problems are being constantly suggested for experimental study, and this field of research offers many opportunities for graduate work.

Chemical Engineering

Through the coöperation of the Department of Chemistry, excellent facilities are offered for studies on chemical engineering problems. Both pure and applied chemistry research problems are available for selection by graduate students who have the degree of Bachelor of Science in Chemical Engineering. Chemical engineering, industrial, inorganic, organic, and physical chemical research investigations are being carried on at all times.

PROGRAM OF STUDY

II. S.B. in Electrical Engineering

FRESHMAN YEAR

		*Class	Laboratory	Preparation	Total
Mathematics 1-2-3E	Algebra, Trigonometry, Analytics	3	3	6	12
Chemistry 1-2E	General Descriptive Chemistry	4fw	4fw	4fw	12fw
English 9abc	Conference Course	2	.....	2	4
History 2-E	Foundations of Modern Civilization	5s	.....	5s	10s
Engineering 1abc	Mechanical Drawing and Descriptive Geometry	.....	6	.....	6
Engineering 3abc	Elementary Mechanics	3	.....	5	8
Engineering 7c	Engineering Inspection-Trips	.....	6s	.....	6s
Engineering 61abc	Introduction to Electrical Engineering	2	2	3	7

SOPHOMORE YEAR

		*Class	Laboratory	Preparation	Total
Mathematics 4-5-6E	Calculus	3	3	6	12
Physics 1-2E	General Physics	3fw	4fw	5fw	12fw
English 10abc	Public Speaking and Writing	2	.....	3	5
Engineering 4abc	Mechanics	3	.....	6	9
Engineering 6abc	Materials of Engineering	2	3fw	3	8
Engineering 22ac	Field Work in Surveying	.....	3fs	.....	3fs
Engineering 32bc	Hydraulics	2ws	2ws	2ws	6ws
Engineering 62abc	Elements of Electrical Engineering	2	2	3	7

SOPHOMORE SUMMER TERM—EIGHT WEEKS

		*Class	Laboratory	Preparation	Total
Engineering 2s	Machine Drawing	.....	12	.....	12
Engineering 62s	Electrical Engineering	.....	18	.....	18

CO-OPERATIVE JUNIOR YEAR

		*Class	Laboratory	Preparation	Total
English 11	Literature and Technical Composition	4	.....	6	10
Economics 1-2-3E	General Economics	4	.....	8	12
Mathematics 56-57-58	Graphical Analysis	.....	2	.....	2
Engineering 5abc	Applied Mechanics	3	.....	3	6
Engineering 63abc	Electrical Machinery	4	.....	8	12
Engineering 73abc	Electrical Laboratory	.....	3	3	6
Engineering 90abc	Steam Machinery	3	3	6	12

Co-operative Industrial Work—Part time on industrial work from September to September, 23 weeks.

*The figures in the table are clock hours. The letters f, w, and s indicate fall, winter, and spring quarters.

SENIOR YEAR

		*Class	Laboratory	Preparation	Total
English 12abc	Conference Course	1	.....	1	2
Commerce 10-11-12	Business Administration	3	.....	6	9
Engineering 64abc	Alternating-Current Machinery and Power Transmission	4	.....	8	12
Engineering 74abc	Alternating-Current Machinery Laboratory	.....	6	6	12
Engineering 75abc	Applications Laboratory	.....	4	4	8
Engineering 84abc	Dynamo Design	2	4	.....	6
Engineering 85a	Electric Circuits	3f	.....	3f	6f
Engineering 86a	Industrial Applications	3f	.....	3f	6f
Engineering 85b	Electrical Measurements	3w	.....	3w	6w
Engineering 86b	Illuminating Engineering	3w	.....	3w	6w
Engineering 85c } Select	Communication Engineering	3s	.....	3s	6s
Engineering 86c } one	Electric Railway Engineering	3s	.....	3s	6s

III. S.B. in Civil Engineering

FRESHMAN YEAR

		*Class	Laboratory	Preparation	Total
Mathematics 1-2-3E	Algebra, Trigonometry, Analytics	3	3	6	12
Chemistry 1-2E	General Descriptive Chemistry	4fw	4fw	4fw	12fw
English 9abc	Conference Course	2	.....	2	4
History 2E	Foundations of Modern Civilization	5s	.....	5s	10s
Engineering 1abc	Mechanical Drawing and Descriptive Geometry	.....	6	.....	6
Engineering 3abc	Elementary Mechanics	3	.....	5	8
Engineering 7c	Engineering Inspection-Trips	.....	6s	.....	6s
Engineering 11abc	Cement Laboratory	.....	3	2	5

SOPHOMORE YEAR

		*Class	Laboratory	Preparation	Total
Mathematics 4-5-6E	Calculus	3	3	6	12
Physics 1-2-3E	General Physics	3	4	5	12
English 10abc	Public Speaking and Writing	2	.....	3	5
Engineering 4abc	Mechanics	3	.....	6	9
Engineering 6abc	Materials of Engineering	2	3	3	8
Engineering 22a	Field Work in Surveying	.....	3f	.....	3f
Engineering 32bc	Hydraulics	2ws	2ws	2ws	6ws

SOPHOMORE SUMMER TERM—EIGHT WEEKS IN CAMP

		*Class	Laboratory	Preparation	Total
Engineering 2s	Engineering Drawing	.....	6	.....	6
Engineering 23s	Railway and Highway Surveying	5	35	.....	40

*The figures in the table are clock hours. The letters f, w, and s indicate fall, winter, and spring quarters.

CO-OPERATIVE JUNIOR YEAR

		*Class	Laboratory	Preparation	Total
English 11	Literature and Technical Composition	4	.....	6	10
Economics 1-2-3E	General Economics	4	.....	8	12
Mathematics 56-57-58	Graphical Analysis	.....	2	.....	2
Engineering 5abc	Applied Mechanics	3	3	3	9
Engineering 60abc	Elements of Electrical Engineering	3	3	6	12
Engineering 90abc	Steam Machinery	2	3	2	7

Co-operative Industrial Work—Part time on industrial work from September to September, 23 weeks.

SENIOR YEAR

		*Class	Laboratory	Preparation	Total
English 12abc	Conference Course	1	.....	1	2
Commerce 10-11-12	Business Administration	3	.....	6	9
Geology 18-19-20	Engineering Geology	3	.....	6	9
Engineering 14abc	Structures	3	.....	2	5
Engineering 24abc	Reinforced Concrete	2	.....	4	6
Engineering 34abc	Hydraulic and Sanitary Engineering	3	.....	4	7
Engineering 44abc	City Planning, Highway Engineering and Railway Engineering	3	.....	3	6
Engineering 15-25-35-45abc	Engineering Design	.....	15	.....	15

VI. S.B. in Mechanical Engineering

FRESHMAN YEAR

		*Class	Laboratory	Preparation	Total
Mathematics 1-2-3E	Algebra, Trigonometry, Analytics	3	3	6	12
Chemistry 1-2E	General Descriptive Chemistry	4fw	4fw	4fw	12fw
English 9abc	Conference Course	2	.....	2	4
History 2-E	Foundations of Modern Civilization	5s	.....	5s	10s
Engineering 1abc	Mechanical Drawing and Descriptive Geometry	.....	6	.....	6
Engineering 3abc	Elementary Mechanics	3	.....	5	8
Engineering 7c	Engineering Inspection-Trips	.....	6s	.....	6s
Engineering 91abc	Mechanical Engineering Laboratory	1	2	3	6

SOPHOMORE YEAR

		*Class	Laboratory	Preparation	Total
Mathematics 4-5-6E	Calculus	3	3	6	12
Physics 1-2-3E	General Physics	3	4	5	12
English 10abc	Public Speaking and Writing	2	.....	3	5
Engineering 4abc	Mechanics	3	.....	6	9
Engineering 6abc	Materials of Engineering	2	3	3	8
Engineering 22ac	Field Work in Surveying	.....	3fs	.....	3fs
Engineering 32bc	Hydraulics	2ws	2ws	2ws	6ws

*The figures in the table are clock hours. The letters f, w, and s indicate fall, winter, and spring quarters.

SOPHOMORE SUMMER TERM—EIGHT WEEKS

		*Class	Laboratory	Preparation	Total
Engineering 2s	Mechanism	.....	12	.....	12
Engineering 91s	Elementary Machine Design	.....	18	.....	18

CO-OPERATIVE JUNIOR YEAR

		*Class	Laboratory	Preparation	Total
English 11	Literature and Technical Composition	4	.....	6	10
Economics 1-2-3E	General Economics	4	.....	8	12
Mathematics 56-57-58	Graphical Analysis	.....	2	.....	2
Engineering 5abc	Applied Mechanics	3	.....	3	6
Engineering 60abc	Electrical Machinery	3	3	6	12
Engineering 93abc	Heat Power Engineering	3	3	6	12

Co-operative Industrial Work—Part time on industrial work from September to September, 23 weeks.

SENIOR YEAR

		*Class	Laboratory	Preparation	Total
English 12abc	Conference Course	1	.....	1	2
Commerce 10-11-12	Business Administration	3	.....	6	9
Engineering 75a	Industrial Applications Laboratory	.....	4f	4f	8f
Engineering 86a	Industrial Applications of Electricity	3f	.....	3f	6f
Engineering 94abc	Advanced Heat Power Engineering	3	4	6	13
Engineering 95b	Power Plants	3w	4w	6w	13w
Engineering 95c	Power Plants Design	1s	4s	.....	5s
Engineering 96abc	Machine Design	2	6	4	12

*The figures in the table are clock hours. The letters f, w, and s indicate fall, winter, and spring quarters .

SUGGESTED OUTLINE OF STUDY FOR ADVANCED STUDENTS

For students who, after taking a pre-engineering course at an accredited liberal arts college, contemplate completing the engineering course in three years, the following subjects are recommended as forming part of the liberal arts curriculum.

Mathematics 1-2-3E....Algebra, Solid Geometry, Trigonometry and Analytical Geometry.
Mathematics 4-5-6E....Differential and Integral Calculus.
English .....A two-year course including public speaking and composition.
Chemistry 1-2E.....General Descriptive Chemistry.
Physics 1-2-3E.....General Physics.
History .....Foundations of Modern Civilization.

As a guide for the general content of the above subject matter, a description of the courses as given in the School of Engineering will be found on pages 33-34. The equivalent of these courses would be taken in any accredited liberal arts college.

PROGRAM OF STUDY FOR ADVANCED STUDENTS

COMBINED FRESHMAN AND SOPHOMORE YEARS

		*Class	Laboratory	Preparation	Total
Engineering 1abc	Mechanical Drawing and Descriptive Geometry	.....	6	.....	6
Engineering 4abc	Mechanics	2	.....	4	6
Engineering 6abc	Materials of Engineering	2	3	3	8
Engineering 7c	Engineering Inspection-Trips	.....	6s	.....	6s
Engineering 22ac	Field Work in Surveying	.....	3fs	.....	3fs
Engineering 32bc	Hydraulics	2ws	2ws	2ws	6ws
Engineering 61abc	Elements of Electrical Engineering (for Mechanical Students)	2	2	3	7
Engineering 62abc	Elements of Electrical Engineering (for Electrical Students)	2	2	3	7
Engineering 91abc	Mechanical Engineering Laboratory (for Mechanical Students)	1	2	3	6

Sophomore Summer Term—Eight Weeks

CIVIL ENGINEERING STUDENTS

		*Class	Laboratory	Preparation	Total
Engineering 2s	Engineering Drawing	.....	6	.....	6
Engineering 23s	Railway and Highway Surveying	5	35	.....	40

ELECTRICAL ENGINEERING STUDENTS

		*Class	Laboratory	Preparation	Total
Engineering 2s	Machine Drawing	.....	12	.....	12
Engineering 62s	Electrical Engineering	.....	18	.....	18

MECHANICAL ENGINEERING STUDENTS

		*Class	Laboratory	Preparation	Total
Engineering 2s	Mechanism	.....	12	.....	12
Engineering 91s	Elementary Machine Design	.....	18	.....	18

The program of study for the junior and senior years for all departments is the same as listed on pages 26-29, 31.

VII. S.B. in Chemical Engineering

FRESHMAN YEAR

		*Class	Laboratory	Preparation	Total
Mathematics 1-2-3E	Algebra, Trigonometry, Analytics	3	3	6	12
Chemistry 1-2E	General Descriptive Chemistry	4fw	4fw	4fw	12fw
Chemistry 31	Qualitative Chemistry	3s	6s	.....	9s
English 9abc	Conference Course	.....	.....	2	2
Engineering 1abc	Mechanical Drawing and Descriptive Geometry	.....	6	.....	6
Engineering 3abc	Elementary Mechanics	3	.....	5	8
Engineering 7c	Engineering Inspection-Trips	.....	6s	.....	6s
Engineering 61abc	Introduction to Electrical Engineering	2	2	3	7

*The figures in the table are clock hours. The letters f, w, and s indicate fall, winter and spring quarters.

SOPHOMORE YEAR

		*Class	Laboratory	Preparation	Tota
Mathematics 4-5-6E	Calculus	3	3	6	12
Physics 1-2-3E	General Physics	3	4	5	12
English 10abc	Public Speaking and Writing	2	.....	3	5
Engineering 4abc	Mechanics	3	.....	6	9
Engineering 6abc	Materials of Engineering	2	3	3	8
Chemical Engineering 2c	Chemical Engineering Equipment and Information	6s	.....	6s	12s
Chemistry 41-42	Quantitative Analysis	3fw	6fw	3fw	12fw

SOPHOMORE SUMMER TERM—EIGHT WEEKS

		*Class	Laboratory	Preparation	Tota
Engineering 2s	Mechanism	.....	12	.....	12
Chemistry 61	Organic**	5	12	.....	17

JUNIOR YEAR

		*Class	Laboratory	Preparation	Total
Chemistry 45	Technical Analysis	3f	6f	3f	12f
Chemistry 81-82	Physical Chemistry	3ws	3ws	8ws	14ws
Chemistry 62	Organic Chemistry	4ws	4ws	8ws	16ws
Chemical Engineering 1b	Fuels, Metallurgy and Metallography	3w	6w	3w	12w
Engineering 75c	Electrical Applications Laboratory	.....	4	4	8
English 11abc	Literature and Technical Composition	4	.....	6	10
Engineering 90abc	Steam Machinery	2	3	2	7
Economics 1-2E	General Economics	4	.....	8	12
Chemical Engineering 3abc	Principals of Chemical Engineering	3	.....	3	6

JUNIOR SUMMER TERM—EIGHT WEEKS

CO-OPERATIVE WORK IN PLANTS

SENIOR YEAR

		*Class	Laboratory	Preparation	Total
Chemistry 11-12	Chemical Technology	3fw	4fw	6fw	13fw
Chemistry 21-22-23	Senior Research	1	8	6	14
Chemical Engineering 6c	Chemical Engineering Laboratory	2s	6s	4s	12s
Chemical Engineering 7c	Special (Optional) Problems	2s	6s	4s	12s
Geology 3-4	Mineralogy	3fw	6fw	3fw	12fw
Commerce 10-11-12E	Business Administration	3	.....	6	9

*The figures in the table are clock hours. The letters f, w, and s indicate fall, winter, and spring quarters.
**Six weeks.

COURSES LEADING TO THE DEGREE OF MASTER OF SCIENCE

I. Master of Science in Civil Engineering.

A. Municipal and Sanitary Engineering.

With the rapid increase in the growth of cities in North Carolina and other southern states, there has come about a wide demand for engineers trained to plan and administer the various technical activities of the modern city; therefore a fifth-year course has been especially designed as a preparation for the important duties of city manager and city engineer. Technical specialists, such as operators of water and sewage treatment plants, will find the specialized courses of the fifth year of much value.

The first four undergraduate years are identical with those in civil engineering. Especial attention is called to the description of courses 34 and 44, in which a thorough treatment is given to the fundamental principles underlying city planning and the design and operation of water works, and sewerage systems, water and sewage treatment plants, garbage and refuse disposal, and drainage. Approved courses in Commerce present the basic facts of business administration which are required of all engineering administrators.

Courses for the graduate year must ordinarily be chosen from among those shown below. At least six courses must be elected in the particular field of sanitary engineering and three courses in a related but distinct field.

Advanced Sanitary Engineering, 130abc.
Research in Hydraulic and Sanitary Engineering, 131abc.
Hydrology, 132a.
Sanitary Chemistry and Biology, 133abc.
Vital Statistics, 135a.
Water Power Engineering, 134abc.
Contracts and Specifications, 100abc.
Bacteriology.
Zoology.
Chemistry.
Commerce.

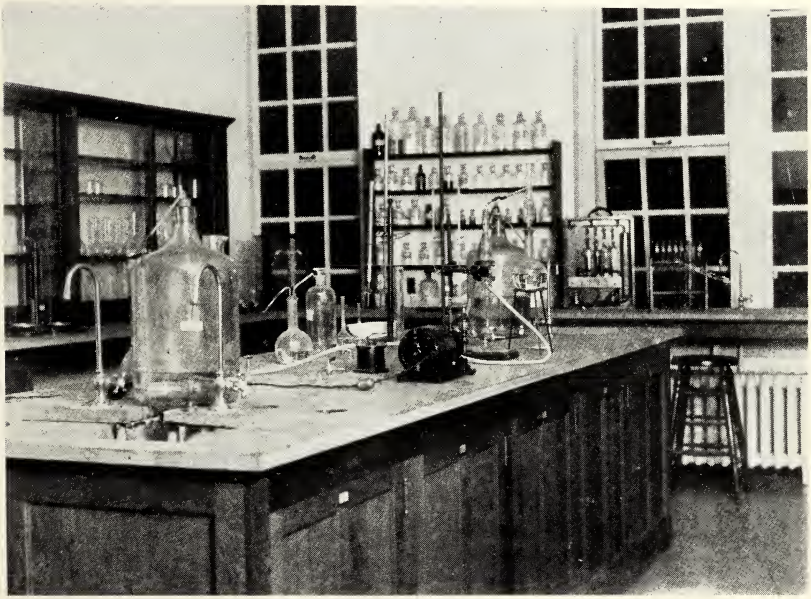
B. Highway Engineering.

North Carolina has assumed a position in roadbuilding as a leader among the states in the Union, and consequently there is a demand for engineers who are trained as specialists in highway construction. Opportunities with the State Highway Commission, county highway commissions, various municipalities, and with contractors handling highway work are open for employment to men who have specialized in highway work. Other states are acknowledging the thoroughness with which North Carolina has carried on its road work, and are looking to this state for a supply of trained men. The closest coöperation exists between the State Highway Commission and the University, and students are brought into contact with the State Highway organization.

The first four undergraduate years are identical with those in the course leading to the B.S. Degree in Civil Engineering. In courses 44 and 45 training in the subject of railway and highway engineering and city planning is given. Course 14 gives the student a working knowledge of the subject of structural design, while course 24 covers the subject of concrete design. Using these courses as a foundation, the student is required in his fifth year to specialize more highly and to acquire a detailed knowledge of the problems of highway construction.

Courses for the graduate year must ordinarily be chosen from among those shown below. At least six courses must be elected in the particular field of highway engineering and three courses in a related but distinct field.

Corner of Laboratory of Sanitary Biology



Corner of Laboratory of Sanitary Chemistry

Detailed Laboratory Study of Highway Materials, Engineering 145abc.
Contracts and Specifications, Engineering 100abc.
Research in Highway Engineering, Engineering 140abc. (This course is open to Research Fellows only and will be substituted by them for 145abc.
Electrical Engineering.
Advanced Steel Structures, Engineering 114abc.
Reinforced Concrete Structures, Engineering 124abc.
Commerce.
Geology.

C. Structural Engineering.

Structural engineering includes the design and construction of all kinds of buildings and bridges, for example typical structures as the Woolworth Building of New York City, Brooklyn and Hell Gate bridges, the immense Panama Canal lock gates. In fact it may be said that the structural engineer would be called upon as a specialist in most all branches of engineering because structures of timber, concrete, or steel are found in the construction of nearly every engineering undertaking. The important branches of concrete and reinforced concrete come under the division of structural engineering.

Courses for the graduate year must ordinarily be chosen from among those shown below. At least six courses must be elected in the particular field of structural engineering and three courses in a related but distinct field.

Advanced Steel Structures, Engineering 114abc.
Advanced Strength of Materials, Engineering 105abc.
Reinforced Concrete Structures, Engineering 124abc.
Contracts and Specifications, Engineering 100abc.
Electrical Engineering.
Mechanical Engineering.
Geology.
Commerce.

II. Master of Science in Electrical Engineering.

Electrical Engineering 164abc.
Electrical Engineering 184abc.
Approved courses in the following departments; the arrangement and number of courses to be decided upon after conference with the departments of Electrical Engineering, Civil Engineering, Chemistry, Physics, Mathematics.

III. Master of Science in Hydro-Electric Engineering

A course leading to the Degree of Master of Science in Civil, Electrical or Mechanical Engineering.

Problems incident to the rapid increase in the development of the great water powers of the South with the accompanying complexities of generation, transmission, and distribution of electric energy have created a wide demand for engineers especially trained in the field of hydro-electric engineering. This course is particularly designed to meet the needs of students intending to enter the service of the various southern power companies, or for engineers now in practice who desire to return for a year of specialized work or research in some of the problems confronting the hydro-electric industry.

The first four undergraduate years are identical with those in either civil, electrical or mechanical engineering. In the graduate year a student will divide his time among subjects suited to his particular needs. Students in the

fifth year will make an inspection trip to and report on various hydro-electric and steam power plants in the state.

Courses for the graduate year must ordinarily be chosen from among those shown below. At least six courses must be elected in the particular field of his choosing and three courses in a related but distinct field.

Water Power Engineering, Engineering 134bc.
Electric Transients, Engineering 164a.
Hyperbolic Functions Applied to Transmission Problems, Engineering 164b.
Design of Transmission Systems, Engineering 164c.
Electrical Engineering Research and Design, Engineering 184abc.
Research in Hydraulic and Sanitary Engineering, Engineering 131abc.
Contracts and Specifications, Engineering, 100abc.
Hydrology, Engineering 34a.
Power Plant Design and Operation, Engineering 95bc.
Alternating Current Machinery and Power Transmission, Engineering 64abc.
Electric Circuits, Engineering 85a.

Courses for the graduate year must ordinarily be chosen from among those shown below. At least six courses must be elected in the particular field of sanitary engineering and three courses in a related but distinct field.

DESCRIPTION OF COURSES

Except as noted below (courses Drawing 1-2 and Engineering 16C, 37C, 38C, 50abc, and 70C) courses in Engineering are open to students in Engineering only.

1abc. MECHANICAL DRAWING AND DESCRIPTIVE GEOMETRY.

Lettering and use of drawing instruments. Descriptive geometry, covering fundamental problems of the point, line, and plane and their appplication to problems of the intersection and development of surfaces. Problems in isometric and perspective projections. *Six laboratory hours a week, fall, winter, and spring quarters.* Credit, 1½ courses. Professor Smith and Mr. Foushee.

1-2. DRAWING. For students in the schools of Commerce and Applied Science only.

This course is designed to help the student interpret and read working drawings. It embodies lettering, the use of drawing instruments, the elementary principles of mechanical drawing, and the reading of typical completed drawings. *Four laboratory hours a week, fall and winter quarters.* Credit, ⅔ course. Professor Smith and Mr. Foushee.

2s. MECHANISM AND ENGINEERING DRAWING. Prerequisite, Engineering 1abc. For electrical and mechanical engineers.

The relative motions of machine parts, including a study of linkages, cams, gears, belts, gear trains, and other mechanisms. *Twelve laboratory hours a week, summer term.* Credit, ⅘ course. Professor Hoefer.

TOPOGRAPHICAL DRAWING AND MAPPING. For civil engineers.

A course consisting of topographical drawing, mapping of boundary surveys, and other drawings of a similar nature. This course is in connection and parallel with Engineering 23s. *Six laboratory hours a week, summer term.* Credit, ½ course. Professor Janda.

3abc. ELEMENTARY MECHANICS.

The basic principles of statics and an elementary course in strength of materials, covering conditions of equilibrium, force, and funicular polygons, center of gravity, friction, beams, and jointed structures. This course correlates with first-year Mathematics and Drawing. *Three lecture hours a week, fall, winter, and spring quarters.* Credit, 1½ courses. Professors Saville, Baity, Smith, and Trimble.

4abc. MECHANICS. Prerequisites, Engineering 3abc and Mathematics 1-2-3E.

The fundamental conceptions of statics including resultants of force systems, equilibrium of force systems, friction, centroids, moments of inertia of areas and bodies. This course correlates with sophomore Mathematics. *Two lecture hours a week, fall, winter, and spring quarters.* Credit, 1½ courses. Professors Hickerson and Trimble.

5abc. APPLIED MECHANICS AND STRENGTH OF MATERIALS. Prerequisites, Engineering 3abc and Mathematics 4-5-6E.

Kinematics and kinetics of particles and rigid bodies, including translation, rotation, and plane motion; the principles of work and energy, impulse, and momentum. The fundamental principles governing the strength and behavior of beams, columns, truss members, shafting, and various kinds of riveted connections. *Three lecture hours a week, fall, winter, and spring quarters.* Credit, 1½ courses. Professor Hickerson.

6abc. MATERIALS OF ENGINEERING.

Constitution, physical properties, and tests of the important materials, such as wood, cement, stone, iron, steel, etc., used in engineering construction; metallurgy of iron and steel and the more important alloys. *Two lecture hours a week, three laboratory hours a week, fall, winter, and spring quarters.* Laboratory fee, $4.00 a quarter. Credit, 1⅔ courses. Professors Janda and Trimble.

7c. INSPECTION TRIPS.

The freshmen students are given an opportunity to become familiar with various types of engineering works by weekly inspection trips during the spring quarter. One afternoon a week is scheduled for inspection trips under the supervision of an engineering instructor, and a second afternoon is devoted to writing a report of the trip under the supervision of the English instructor. *Six laboratory hours a week, spring quarter.* Credit, ¼ course. Professor Janda, Chairman, and members of the engineering and English staffs.

11abc. CEMENT LABORATORY.

Laboratory tests of cement and concrete, and analyses of concrete materials. *Three laboratory hours a week, fall, winter, and spring quarters.* Laboratory fee, $3.00 for winter and spring quarters. Credit, 1½ courses. Professors Janda and Trimble.

14abc. STRUCTURES. Prerequisite, Engineering 5abc.

Graphical and analytical determination of stresses occurring in engineering structures, such as roofs, bridges, retaining walls, etc. The design of simple structures in steel and timber. *Three lecture hours a week, fall, winter, and spring quarters.* Credit, 1½ courses. Professor Braune.

15abc. ENGINEERING DESIGN.

Application of principles in course 14 to specific problems in the design of roofs, bridges, retaining walls, water towers, and other structures. *Six laboratory hours a week, fall and spring quarters; three laboratory hours a week, winter quarter.* Credit, 1¼ courses. Professors Braune and Smith.

16c. PLANE TABLE SURVEYING AND MAPPING.

Preparation and interpretation of topographical maps. Lectures and field work. *Four laboratory hours a week, spring quarter.* Laboratory fee, $2.00. Credit, ½ course. Professor Trimble.

22ac. FIELD WORK IN SURVEYING. Prerequisite, Mathematics 1-2-3E.

Practice in the use and adjustments of tape, level, transit, plane table, etc. The making and reading of maps; meridian and latitude determination. *Three laboratory hours a week, fall and spring quarters.* Laboratory fee, $3.00 a quarter. Credit, ⅔ course. Professor Trimble.

23s. RAILWAY AND HIGHWAY SURVEYING—SUMMER ENGINEERING CAMP. Prerequisite, Engineering 22a.

Instruction in plane, railway, and highway surveying is given during eight weeks of the summer term following the sophomore year. The course includes the following subjects: I. Chaining; differential, profile, and cross-section leveling; plane-table, transit, and stadia topographic surveys; solar and stellar observations for the determination of meridian and latitude; triangulation including base line measurement; measurement of stream discharge; hydrographic surveying. II. Simple, compound, reversed, spiral, and vertical curves; frogs and turnouts; reconnaissance survey; preliminary survey; paper location; final location; mass diagram and earthwork computation; slope-staking; estimate of quantities and cost. *Five lecture hours a week, forty laboratory hours a week, summer term.* Laboratory fee, $10.00. Credit, 3½ courses. Professor Janda.

24abc. REINFORCED CONCRETE STRUCTURES. Prerequisite, Engineering 5abc.

Development of the mathematical principles involved in the design of plane and reinforced concrete beams, slabs, columns, foundations, retaining walls, arches, and girder bridges. *Two lecture hours a week, fall, winter, and spring quarters.* Credit, 1½ courses. Professor Hickerson.

25abc. ENGINEERING DESIGN.

Application of the principles in course 24 to specific problems in the design of reinforced concrete buildings and bridges. *Three laboratory hours a week, fall, winter, and spring quarters.* Credit, ¾ course, Professor Hickerson,

32bc. HYDRAULICS. Prerequisite, Mathematics 4-5-6E.

The principles of flow of water through orifices, weirs, tubes, nozzles, pipes, and open channels as applied to measurement of water to hydraulic engineering. The fundamental principles of impulse wheels, reaction turbines, and centrifugal pumps. *Two lecture hours a week, three laboratory hours a week, winter and spring quarters.* Laboratory fee, $2.00 a quarter. Credit, 1⅓ courses. Professors Saville and Baity.

34abc. HYDRAULIC AND SANITARY ENGINEERING. Prerequisite, Engineering 32bc.

The fundamentals of design, construction, and operation of water supply and sewerage systems as applied to municipalities and rural communities. Attention is given to preliminary studies of rainfall, stream flow, and storage as applied to both water supply and water power. *Three lecture hours a week, fall, winter, and spring quarters.* Credit, 1½ courses. Professors Saville and Baity.

35abc. SANITARY ENGINEERING DESIGN.

Application of principles in course 34 to specific problems in the general layout of simple projects for water works and sewerage. Considerable time is spent in the laboratory performing routine tests of water and sewage. *Three laboratory hours a week, fall and spring quarters; six laboratory hours a week, winter quarter.* Laboratory fee, $3.00, fall quarter; $4.00 winter and spring quarters. Credit, 1 course. Professors Saville and Baity.

37C. STREETS, HIGHWAYS, AND CITY PLANNING.

A brief course for students in the School of Commerce who elect the Municipal Administration group. *Three lecture hours a week, fall quarter.* Credit, ½ course. Professor Janda.

38C. MUNICIPAL WATER SUPPLIES AND SANITATION.

A brief course for students in the School of Commerce who elect the Municipal Administration Group. *Three lecture hours a week, winter quarter.* Credit, ½ course. Professor Saville.

44a. CITY PLANNING.

Growth of cities; street plans; subdivisions; housing; recreation facilities; zoning; transportation terminals; traffic regulations. *Three lecture hours a week, fall quarter.* Credit, ½ course. Professor Janda.

44b. HIGHWAY ENGINEERING. Prerequisite, Engineering 23s, or equivalent experience.

A study of location, construction, and maintenance of the various types of highways; characteristics of road materials; highway administration, legislation, and organization. *Three lecture hours a week, winter quarter.* Credit, ½ course. Professor Janda.

44c. RAILWAY ENGINEERING. Prerequisite, Engineering 23s, or equivalent experience.

Roadbed construction; ballast; ties and tie-plates; rails; frogs and switches; fences and cattleguards; bridge and trestle floors; track signs, etc. *Three lecture hours a week, spring quarter.* Credit, ½ course. Professor Janda.

45abc. ENGINEERING DESIGN.

Application of principles in course 44 to specific problems in city planning and the physical testing of road materials. *Three laboratory hours a week, fall, winter, and spring quarters.* Laboratory fee, $3.00 a quarter. Credit, ¾ course. Professor Janda.

50abc. ELECTRICAL MEASUREMENTS. Prerequisites, Physics 1-2-3E, and Mathematics 4E.

A study of the fundamental principles of electric circuits and apparatus, designed especially for students in Chemistry. The laboratory work will include the methods of electrical measurements used in the chemical laboratory, together with the application of electrical energy for heating and control. *Three lecture hours a week, two laboratory hours a week, fall, winter, and spring quarters.* Laboratory fee, $5.00 a quarter. Credit, 2¼ courses. Mr. Smiley.

60abcs. ELEMENTS OF ELECTRICAL ENGINEERING. Prerequisite, Mathematics 4-5-6E.

A study of the generation, transmission, control, and utilization of electrical energy, designed especially to meet the needs of students in civil and mechanical engineering. Textbook: Gray's *Principles and Practice of Electrical Engineering. Three lecture hours a week, three laboratory hours a week, fall, winter, spring, and summer quarters.* Credit, 3 courses. Professor Hoefer.

61abc. INTRODUCTION TO ELECTRICAL ENGINEERING.

The aim of this course is to give the student an acquaintance with the materials, apparatus, and terminology used in electrical engineering. The fundamental principles of current, voltage, resistance, energy, and power are studied by means of practical problems with commercial apparatus. Practical work in wiring, together with a study of the National Electric Code will be given in the spring quarter. *Two lecture hours a week, two laboratory hours a week, fall, winter, and spring quarters.* Laboratory fee, $4.00 a quarter. Credit, 1½ courses. Messrs. Smiley, Holshouser, and Hazell.

62abcs. ELEMENTS OF ELECTRICAL ENGINEERING. Prerequisites, Engineering 61abc, and Mathematics 1-2-3E.

A study of the fundamentals of direct-current generators and motors, followed by the elements of alternating-current circuits in the spring quarter. The laboratory work consists of studies of the operating characteristics of direct-current machines; direct-current measurements; the effect of resistance, inductance, capacity, and frequency in alternating-current circuits. Textbooks: Timbie and Bush. *Two lecture hours a week, two laboratory hours a week, fall, winter, spring, and summer quarters.* Laboratory fee, $4.00 a quarter. Credit, 2¼ courses. Professor Lear and Mr. Stewart.

63abcs. ELECTRICAL MACHINERY. Prerequisites, Engineering 62abcs and Mathematics 4-5-6E.

A thorough study of direct-current machines, followed by the elements of alternating-current circuits and machines, with special attention to the alternator, transformer, and induction motor. Textbooks: Langsdorf and Lawrence I. *Four lecture hours a week, fall, winter, spring, and summer quarters.* Credit, 3 courses. Professor Lear and Mr. Smiley.

64abc. ALTERNATING-CURRENT MACHINERY AND POWER TRANSMISSION. Prerequisites, Engineering 63abcs and Mathematics 4-5-6E.

A thorough study of the theory of the alternator, transformer, synchronous motor, synchronous converter, induction motor and generator, and the various types of single-phase commutator motor; the electrical principles involved in long distance power transmission, with an introduction to the treatment of long lines by means of hyperbolic functions. *Five lecture hours a week, fall, winter, and spring quarters.* Credit, 3 courses. Professor Daggett.

70C. MUNICIPAL LIGHTING, POWER, AND PUBLIC UTILITIES.

A brief course for students in the School of Commerce who elect the Municipal Administration group. *Three lecture hours a week, spring quarter.* Credit, ½ course. Professor Daggett.

73abcs. JUNIOR ELECTRICAL LABORATORY. Corequisite, Engineering 63abcs.

One laboratory experiment and report a week throughout the year. Performance characteristics of direct-current generators and motors; parallel operation of shunt and compound machines; heat runs; pump-back tests; location of faults. *Three laboratory hours a week, fall, winter, spring, and summer quarters.* Laboratory fee, $5.00 a quarter. Credit, 1½ courses. Professor Lear and Mr. Smiley.

74abc. ALTERNATING-CURRENT MACHINERY LABORATORY. Corequisite, Engineering 64abc.

One experiment and report a week throughout the year. Measurement of alternating-current circuit constants; series and parallel resonance; investigation of e.m.f. and current wave shapes by means of the oscillograph; harmonics in polyphase circuits; regulation, hearing, and efficiency tests on the transformer, alternator, synchronous motor and converter, induction motor; opera-

ting characteristics of the induction generator, single phase commutator motor, mercury arc rectifier. *Six laboratory hours a week, fall, winter, and spring quarters.* Laboratory fee, $7.00 a quarter. Credit, 3 courses. Professor Daggett and Mr. Smiley.

75abc. ELECTRICAL APPLICATIONS LABORATORY. Corequisites, Engineering 85 and 86.

One laboratory experiment and report a week, accompanying the courses in special fields; a considerable portion of the time will be spent in the standardization laboratory in calibration tests on direct-current and alternating-current measurements instrument, magnetic measurements, iron loss, and instrument transformers. *Four laboratory hours a week, fall, winter, and spring quarters.* Laboratory fee, $3.00 a quarter. Credit, 1½ courses. Professor Daggett and Mr. Smiley.

84abc. DYNAMO DESIGN. Corequisite, Engineering 63abcs.

Electrical, mechanical, and economic questions involved in the design of electrical machinery; the effect of the design constants on the proportions and operation of machines. Each student will be required to make complete calculations for a d.c. generator or motor, a transformer, and an alternator. Reference book: Gray. *Two lecture hours a week, four laboratory hours a week, fall, winter, and spring quarters.* Credit, 1½ courses. Professor Daggett.

85a. ELECTRIC CIRCUITS. Prerequisites, Engineering 63abcs and Mathematics 4-5-6E or equivalent.

A mathematical study of the fundamental phenomena in the electric, magnetic, dielectric, and thermal circuits, emphasizing the circuital relations common to all. Considerable attention will be devoted to the application of complex quantities to alternating-current circuits. *Three lecture hours a week, fall quarter.* Credit, ⅓ course. Professor Daggett.

85b. ELECTRICAL MEASUREMENTS. Prerequisite, Engineering 85a.

Theory, calibration, and use of instruments for the measurement of current, potential difference, power, and energy; bridge methods of measuring resistance, inductance, and capacitance; instrument transformers: magnetic measurements; dielectric tests; cable testing. Textbook: Laws. *Three lecture hours a week, winter quarter.* Credit, ⅓ course. Professor Daggett.

85c. COMMUNICATION ENGINEERING. Senior elective.

A study of the fundamentals involved in the transmission of intelligence by telegraph, telephone, and radio; local and central office equipment for manual and machine switching systems; elements of telegraph and telephone transmission; laws of oscillatory circuits; radio transmission; study of the electron tube as detector, amplifier, and oscillator. *Three lecture hours a week, spring quarter.* Credit, ⅓ course. Professor Daggett.

86a. INDUSTRIAL APPLICATIONS. Prerequisite, Engineering 63abcs.

Selection, arrangement and control of central station equipment; application and control of d.c. and a.c. motors for textile mills, steel mills, machine shops, etc.; industrial heating; electric furnaces; electric welding. *Three lecture hours a week, fall quarter.* Credit, ⅓ course. Professor Lear.

86b. ILLUMINATING ENGINEERING. Prerequisite, Engineering 63abcs.

A study of the physical, physiological, and psychological principles of light and illumination; comparison of light sources; photometry; design of illumination systems for various commercial purposes. *Three lecture hours a week, winter quarter.* Credit, ⅓ course. Professor Lear.

86c. ELECTRIC RAILWAY ENGINEERING. Senior elective.

Design of electric railway systems; train resistance; speed-time curves; power requirements; motor equipment and control; distribution systems; main-line electrification. *Three lecture hours a week, spring quarter.* Credit, ⅓ course. Professor Lear.

90abc. STEAM MACHINERY. Prerequisites, Mathematics 4-5-6E and Physics 1-2-3E.

A course in the fundamentals of steam-power and power-plant machinery, designed especially for the needs of students in civil and electrical engineering. Textbook: Allen and Bursley. *Three lecture hours a week, three laboratory hours a week, fall, winter, and spring quarters.* Laboratory fee, $5.00 a quarter. Credit, 3 courses. Professor Hoefer and Mr. Urbston.

91abc. MECHANICAL ENGINEERING LABORATORY.

An introductory course including problem and laboratory work; fundamentals of steam and gas engineering; calibration of instruments and elementary tests of power plant machinery. *One lecture hour a week, two laboratory hours a week, fall, winter, and spring quarters.* Laboratory fee, $2.00 a quarter. Credit, 1 course. Professor Hoefer.

91s. ELEMENTARY MACHINE DESIGN. Prerequisite, Engineering 1abc. Corequisite, Engineering 2s.

For mechanical engineers.

A study of the elementary parts of machines, including riveted joints, screws, keys, axles, shafts, gearing, belting, springs, and power transmissions. Sizes of parts are calculated both on the basis of the principles of mechanics and on the basis of accepted empirical methods. *Eighteen laboratory hours a week, summer term.* Credit, 1¼ courses. Professor Hoefer.

93abc. HEAT POWER ENGINEERING. Prerequisite, Mathematics 4-5-6E.

A study of the laws governing the transformation of heat into mechanical energy, properties of gases and vapors; gas and vapor cycles; power, efficiency, and performance of heat engines; study of steam engines, steam turbines, and gas engines; fuels and combustion; boilers and accessories; gas producers, feed water heaters and purifiers, condensers, compressed air, and refrigeration. Textbook: Hirschfeld and Barnard. *Four lecture hours a week, three laboratory hours a week, fall, winter, spring, and summer quarters.* Laboratory fee, $5.00 a quarter. Credit, 3 courses. Professor Hoefer.

94abc. ADVANCED HEAT POWER ENGINEERING. Prerequisite, Engineering 93abc.

A continuation of Engineering 93abc. An advanced study of power plant equipment, including calculations used in the design and application of such equipment. *Three lecture hours a week, four laboratory hours a week, fall, winter, and spring quarters.* Laboratory fee, $5.00 a quarter. Credit, 3 courses. Professor Hoefer.

95bc. POWER PLANTS.

A study of load conditions and estimation of power requirements. On the basis of comparative economy of different types of power plant apparatus, a choice is made of boilers, turbines, pumps, etc., to meet the demands of the given load. These are properly arranged in a plant lay-out and a study made of fixed charges and operating costs. *Three lecture hours a week, four laboratory hours a week, winter quarter; one lecture hour a week, four laboratory hours a week, spring quarter.* Credit, 1½ courses. Professor Hoefer.

Radio Station 4-W

Freshman Electrical Laboratory

96abc. MACHINE DESIGN. Prerequisites, Engineering 2s, 5abc and 91s.

A continuation of Engineering 91s. Further study of methods of calculation of form and size, based on load to be carried, of machine parts. The design of a complete machine is carried through, including calculations and preparation of working drawings. *Two lecture hours a week, six laboratory hours a week, fall, winter, and spring quarters.* Credit, 3 courses. Professor Hoefer.

CHEMICAL ENGINEERING COURSES

1b. FUELS, METALLURGY, AND METALLOGRAPHY. Prerequisite, Chemistry 45.

This course takes up the study of the preparation, combination, and utilization of fuels and their costs; the microscopic structure of ferrous and nonferrous alloys and the effects of composition, heat treatment, and mechanical work upon the structures and the physical properties of the ferrous alloys. A portion of the course is devoted to laboratory study and heat balance studies on power plants. *Nine hours a week, winter quarter.* Laboratory fee, $10.00. Credit, 1 course. Professor Vilbrandt.

2c. CHEMICAL ENGINEERING EQUIPMENT AND INFORMATION.

A study of different types of equipment and materials of construction, such as wood, cement, stone ware, enamel ware, etc., such as are used in chemical industries. A source of information study on patent literature, government reports, bibliographies, trade catalogues, abstract journals, resources of libraries, activities of technical organizations. A series of inspection trips to chemical industries in this and nearby states will be taken by the group, written reports to be made on the survey. *Five hours a week, spring quarter.* Credit, 1 course. Professor Vilbrandt.

3abc. PRINCIPLES OF CHEMICAL ENGINEERING. Prerequisites, Chemical Engineering 1b and 2c.

A study of the theories of combustion, fluid flow, heat flow, filtration, evaporation, distillation, etc. *Three hours a week, fall, winter, and spring quarters.* Credit, 1½ courses. Professor Vilbrandt.

6c. CHEMICAL ENGINEERING LABORATORY. Prerequisites, Chemical Engineering 1b, 2c, 3abc, and 11-12.

Efficiency studies on chemical equipment, plant erection studies, and unit process work in the laboratory. *Eight hours a week, spring quarter.* Laboratory fee, $10.00. Credit, 1 course. Professor Vilbrandt.

7c. SPECIAL PROBLEMS. Corequisite, Chemical Engineering 6c.

Reading, reports and laboratory work on selected chemical engineering subjects. A group of optional studies is available for the selection of the students, such as studies of dyes, cellulose, foods, ceramics, petroleum, pyrometry, and electrochemistry. *Six hours a week, spring quarter.* Laboratory fee, $10.00. Credit, 1 course. Professor Vilbrandt.

11-12. CHEMICAL TECHNOLOGY. Prerequisites, Chemistry 45, 61, 62, 81 and 82.

A descriptive study of the processes and manufacturing methods, together with the economics of the more important industries based upon inorganic and organic chemical technology. Laboratory work on special plant problems. *Six hours a week, fall and winter quarters.* Laboratory fee, $7.00 a quarter. Credit, 2 courses. Professor Vilbrandt.

NON-ENGINEERING SUBJECTS

Chemistry

1-2E. GENERAL DESCRIPTIVE CHEMISTRY.

An introduction to the study of the principal non-metallic and metallic elements and their compounds with special emphasis on problems. Required of engineering students. Lectures with laboratory work. *Six hours a week, fall and winter quarters.* Laboratory fee, $5.00 a quarter. Credit, 2 courses. Professors Bell and Edmister.

31. QUALITATIVE ANALYSIS. Prerequisite, Chemistry 1-2.

Laboratory work and lectures. *Five hours a week, fall or spring quarter.* Laboratory fee, $10.00. Credit, 1 course. Professor Dobbins.

41. ELEMENTARY QUANTITATIVE ANALYSIS. Prerequisite, Chemistry 31.

Gravimetric analysis. Laboratory work, lectures, and stoichiometric exercises. *Five hours a week, fall quarter.* Laboratory fee, $10.00. Credit, 1 course. Professor Dobbins and Mr. Mebane.

42. ELEMENTARY QUANTITATIVE ANALYSIS. Prerequisite, Chemistry 41.

Volumetric analysis. Laboratory work, lectures, and stoichiometric exercises. *Five hours a week, winter quarter.* Laboratory fee, $10.00. Credit, 1 course. Professor Dobbins.

45. TECHNICAL QUANTITATIVE ANALYSIS. Prerequisites, Chemistry 41 and 42.

Water, oil, fuel, and gas analysis and assaying. *Five hours a week, fall quarter.* Laboratory fee, $7.00. Credit, 1 course. Professor Vilbrandt and Mr. Pickett.

61. ORGANIC CHEMISTRY. Prerequisite, Chemistry 31.

The Aliphatic Series. Required of all chemical engineering students. *Six hours a week, winter quarter.* Laboratory fee, $10.00. Credit, 1 course. Professor Wheeler and Mr. Bost.

62. ORGANIC CHEMISTRY. Prerequisite, Chemistry 61.

The Carbocyclic and Heterocyclic Series. *Five hours a week, spring quarter.* Laboratory fee, $10.00. Credit, 1 course. Professor Wheeler and Mr. Bost.

81. PHYSICAL CHEMISTRY. Prerequisites, Chemistry 41 and 42.

Study of the properties of solids, liquids, and gases, and of their relation to chemical constitution. *Five hours a week, winter quarter.* Laboratory fee, $4.00. Credit, 1 course. Professor Bell and Mr. Crockford.

82. PHYSICAL CHEMISTRY. Prerequisite, Chemistry 81.

The theory of solution, the phase rule. *Five hours a week, spring quarter.* Laboratory fee, $4.00. Credit, 1 course. Professor Bell and Mr. Crockford.

21-22-23. RESEARCH FOR SENIORS. Prerequisites, Chemistry 45, 61, 62, 81 and 82, Chemical Enginering 1b and 2c.

Original investigations. *Six hours a week, fall, winter, and spring quarters.* Laboratory fee, $10.00 a quarter. Credit, 3 courses. Professors Bell, Wheeler, Cameron, Dobbins, and Vilbrandt.

Economics

1-2E. GENERAL ECONOMICS.

This course is planned to give a general understanding of the organization of our economic life and the fundamental principles underlying it. An analysis is made of consumption, production, and distribution of the elements which determine value and price with a brief introduction to money, banking and credit, monopoly, business combinations, transportation, labor problems, and economic reform. *Four lecture hours a week, fall, winter, and spring quarters.* Credit, 2 courses. Professor Lear.

10-11-12. BUSINESS ADMINISTRATION. For students in the School of Engineering. Prerequisite, Economics 1-2.

The elements of business organization with emphasis on the corporation, its nature, its promotion, its financing, and its operation. Internal organization with special reference to methods of control, managerial accounting, cost analysis, financing of current operations, valuation and methods of appraisal, depreciation, sinking funds, and the interpretation of financial statements. The economics of locating and managing industrial plants, the handling of the labor factor through specialized personnel administration, and the relations existing between consumers and producers. Open only to engineering students. *Three lecture hours a week, 1½ laboratory hours a week, fall, winter, and spring quarters.* Credit, 2 courses. Professor Schwenning.

English

9abc. COMPOSITION.

The mechanics of writing studied through class work and conferences on inspection-trip reports and other written exercises of the freshmen year in engineering courses. During the winter and spring quarters certain examples of modern scientific writing are also studied. *Two lecture hours a week and conferences, every quarter.* Credit, 1½ courses. Mr. Harris, Chairman, Messrs. Horner, Pochmann, and Lyons.

10abc. PUBLIC SPEAKING AND WRITING.

A study of the principles of argumentation and practice in the application of these principles to speaking and writing, with emphasis on the forms used by the engineer. Attention will also be paid to voice, gesture, and the relations of speaker and audience. Required of sophomores in engineering. *Three lecture hours a week, fall, winter, and spring quarters.* Credit, 1½ courses. Mr. Olsen.

11abc. LITERATURE AND TECHNICAL COMPOSITION.

A course designed to make clear the relation between literature and science, both by extensive and intensive reading of the classics of English, scientific literature, and by actual practice in writing technical and professional forms. Required of juniors in engineering courses. *Four lecture hours a week, fall, winter, and spring quarters.* Credit, 2 courses. Professor Howell.

12abc. CONFERENCE COURSE.

Conference work for seniors in engineering. Discussion of literature. Credit, ½ course. Professor Howell.

Geology

3-4. MINERALOGY. Prerequisite, Chemistry 1-2.

Crystallography, physical and chemical properties of minerals, blow-pipe analysis. Lectures, laboratory, and field work. *Five hours a week, fall and winter quarters.* Laboratory fee, $5.00 a quarter. Credit, 2 courses. Professor MacCarthy.

18-19-20. ENGINEERING GEOLOGY.

This course includes a study of the common rocks; of fuels and building materials; of dynamical and structural geology, with emphasis on the phases more directly applicable to engineering problems; of applied meteorology. *Three lecture hours a week, fall, winter, and spring quarters.* Laboratory fee, $3.50 a quarter. Credit, 1½ courses. Professor Prouty.

History

2E. FOUNDATIONS OF MODERN CIVILIZATION.

A course dealing with the fundamental factors in modern civilization. Beginning with an analysis of the changes wrought by the French Revolution, the emphasis of the course will rest upon the industrial revolution, the rise of nationalism and democracy, the growth of modern imperialism, and the course and tendencies of modern international relations. Textbooks, lectures, and readings. *Six lecture hours a week, spring quarter.* Credit, 1 course. Professor Graham.

Mathematics

1E. PLANE AND SPHERICAL TRIGONOMETRY. Required of freshmen in engineering courses and in chemistry.

Five hours a week, fall quarter. Credit, 1 course. Professors Hobbs, Winsor, and Linker.

2E. COLLEGE ALGEBRA. Required of freshmen in engineering courses and in chemistry.

Special emphasis upon graphical representation of functions. *Five hours a week, winter quarter.* Credit, 1 course. Professors Hobbs, Winsor, and Linker.

3E. ANALYTIC GEOMETRY. Required of freshmen in engineering courses and in chemistry.

Five hours a week, spring quarter. Credit, 1 course. Professors Hobbs, Winsor, and Linker.

4-5-6E. CALCULUS FOR ENGINEERING STUDENTS. Required of sophomores in engineering courses and in chemistry (4E only for the latter). Prerequisite, Mathematics 3 or 3E.

The first quarter is devoted to a study of the derivative and its applications to geometry and mechanics, expansion of functions, partial differentiation; the second deals chiefly with the definite integral and its application; the third consists of engineering problems involving calculus, together with an elementary treatment of differential equations. *Six lecture hours a week, fall, winter, and spring quarters.* Credit, 3 courses. Professors Hobbs and Linker.

56-57-58. GRAPHICAL ANALYSIS. Prerequisite, Mathematics 5 or equivalent.

A study of alignment charts and of equations determined from empirical data, with a brief treatment of the method of least squares. *Two lecture hours a week, fall, winter, and spring quarters.* Credit, ¾ course. Professor Winsor.

Physics

1-2-3E. PHYSICS FOR ENGINEERING STUDENTS. Required of engineering sophomores. Prerequisite, Mathematics 1-2-3E or equivalent. This is a course given with special reference to the needs of students of engineering, both in the lecture work and in the laboratory, while a great deal of problem work is given on subjects dealing with engineering. *Four lecture hours a week, two laboratory hours a week, fall, winter, and spring quarters.* Laboratory fee, $2.50 a quarter. Credit, 3 courses. Professor Plyler and Mr. Trawick.

COURSES FOR GRADUATE STUDENTS

100abc. CONTRACTS AND SPECIFICATIONS.

A course covering the laws of contracts, a detailed study of methods of writing correct specifications, the matter of securing or submitting bids, and the subject of bid bonds. Credit, 1½ courses. Professors Braune, Saville, and Janda.

105abc. ADVANCED STRENGTH OF MATERIALS. Prerequisite, Engineering 5abc.

General theory of flexure, combined stresses, Lamé's theory for thick hollow cylinders, flexure of curved beams; and other theoretical and empirical matter on the general subject of strength of materials that is not treated exhaustively in the undergraduate curriculum of most engineering schools. Credit, 1½ courses. Professor Hickerson.

114abc. ADVANCED STEEL STRUCTURES. Prerequisites, Engineering 14abc and Engineering 24abc.

Secondary stresses and statically indeterminate structures, including steel arches, cantilever, suspension and movable bridges. Credit, 1½ courses. Professors Braune and Hickerson.

124abc. REINFORCED CONCRETE STRUCTURES. Prerequisites, Engineering 14abc and Engineering 24abc.

A study of the theory and design of multiple arch dams, domes, rigidly connected frames, unsymmetrical bridges, etc. Credit, 1½ courses. Professor Hickerson.

130abc. SANITARY ENGINEERING. Prerequisites, Engineering 34abc and Engineering 35abc, or equivalent.

An advanced course in the design and operation of water supply and sewerage systems, and water and sewage purification plants, including preliminary studies, design of piping, pumps and filters, water rates, leakage surveys, financial management, etc. Occasional lectures will be given by practicing engineers and waterworks superintendents. Credit, 1½ courses. Professors Saville and Baity.

131abc. RESEARCH IN HYDRAULIC AND SANITARY ENGINEERING. Prerequisites, Engineering 34abc and 35abc, or equivalent.

For graduate or special students desiring to conduct investigations in hydrology, water or sewage treatment, or stream pollution. Laboratory fee $5.00 a quarter. Credit, 1 to 3 courses. Professors Saville and Baity.

132a. HYDROLOGY. Prerequisites, Engineering 34abc and Engineering 35abc, or equivalent.

A detailed study of rainfall, stream flow, meteorology, and other factors influencing hydrological investigations. The application of modern statistical methods to such problems is particularly stressed. Laboratory fee, $2.00. Credit, ½ course. This course may be continued for additional credit. Professor Saville.

133abc. SANITARY CHEMISTRY AND BIOLOGY FOR ENGINEERING STUDENTS. Prerequisites, Chemistry 1-2E, Engineering 34abc and Engineering 35abc, or equivalent.

A course designed to give intensive training in the laboratory methods employed in sanitary engineering practice. The work includes microscopical examinations; physical, chemical, and bacteriological determination on water, air, milk, sewage, and industrial wastes; the analysis of sand and gravel for filtration purposes; limnological studies of streams and reservoirs; stream pollu-

tion investigations; and the application of laboratory tests to the control of sanitary works. Class and laboratory exercises are supplemented by field work and plant inspections. Laboratory fee, $5.00 per quarter. Credit, 1 to 3 courses. Professor Baity.

134bc. WATER POWER ENGINEERING. Prerequisites, Engineering 132a or equivalent.

The investigation and design of water power developments, including preliminary hydrological studies, investigation of dam foundation, dam design, characteristics and selection of turbines, etc. A complete report will be prepared, including estimated cost of development, market for power, relation to other power systems and financing. This course may be followed by Engineering 164. Laboratory fee, $2.00 per quarter. Credit, 1 course. Professor Saville.

140abc. RESEARCH IN HIGHWAY ENGINEERING.

Investigation of materials in highway engineering through coöperation with the Highway Commission. This course is open to research fellows only. Fellowships will be awarded to worthy graduate students who can present the proper qualifications. Credit, 1 to 3 courses. Professors Braune and Janda.

145abc. DETAILED LABORATORY STUDY OF HIGHWAY MATERIALS.

The students will be given problems for investigation that are being constantly suggested in the scientific construction and betterment of highways. Credit, 1 to 3 courses. Professor Janda.

164a. ELECTRIC TRANSIENTS.

The mathematical theory of the phenomena of the transient state met with in the operation of electric circuits and machines; training in the technique of the oscillograph by the taking of a large number of oscillograms of characteristic transient phenomena. Laboratory fee, $10.00. Credit, 1 course. Professor Daggett.

164b. HYPERBOLIC FUNCTIONS APPLIED TO TRANSMISSION PROBLEMS.

Use of hyperbolic functions of complex variables in the calculation of long distance transmission systems. Power relations in long lines; design of artificial lines. Credit, 1 course. Professor Daggett.

164c. DESIGN OF TRANSMISSION SYSTEMS.

Economic principles involved in the preliminary layout; insulation and lightning protection; sag of conductors; mechanical design of poles and towers. Credit, 1 course. Professor Daggett.

184abc. ELECTRICAL ENGINEERING RESEARCH AND DESIGN.

The solution of one or more definite problems in some particular field of electrical engineering. The work of this course will be outlined, as far as possible, to suit the needs of the individual student, and will consist of original investigations, designs, or the economic study of some existing electric power plant. Credit, 1 to 3 courses. Professors Daggett and Lear.

194abc. ENGINEERING THERMODYNAMICS.

Advanced thermodynamics, with particular reference to application to steam turbine design, internal combustion engines, refrigerating machinery, heat transfer, and heating and ventilating systems. Credit, 1½ courses. Professor Hoefer.

195abc. ADVANCED MECHANICAL ENGINEERING LABORATORY.

Special experimental investigations in heat-power, refrigerating, and heating and ventilating equipment. Credit, 1 to 3 courses. Professor Hoefer.